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PHOTOGRAPHIC AERIAL ASSESSMENT 42.

FC

FIRST SUPPLEMENT

TO

EQUIPMENT MANUAL

FOR

AIRBORNE INSTALLATIONS (of 1945, NOa(s) 7632)

NOa(s) 8251

Aerial Measurements Laboratory

Northwestern University

Evanston, Illinois

May 1949

10/25/55

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EXHIBITS

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ADDITIONAL GLOSSARY FOR Mk III AND Mk IV

Because of technical differences among the several synchronizing systems it has been necessary to either revise existing definitions or add new ones as given in the following:

AUTOMATIC-MANUAL BOX (AMB): Component of FLINK, mounted in fighter cockpit. When on AUTOMATIC the fighter camera system is tied to the bomber via the FLINK-BLINK; when on MANUAL, the fighter camera control comes from the FCU.

BLINK (Bomber link): Components in bomber needed to transmit camera control signals to fighter. These comprise that part of SU furnishing READY, START, TIMING, and CATALOG signals, and the BLINK transmitter (modified ARW 3 drone transmitter).

CATALOGING MARKS, FILM: Small dots on the film obtained from each camera, used for identifying each attack of a given flight, the number of dots corresponding to the attack number.

CATALOGING MARKS, OSCILLOGRAPH TAPE: Small trace deflections in one direction, representing the time the current is flowing through the choke coil, followed by a larger deflection of shorter duration in the opposite direction because of the voltage surge firing the lamp.

FLASH UNIT: Any unit used for furnishing the high intensity illumination of short duration required for photography of dials.

FLINK (Fighter link): Components in fighter needed to receive and convert BLINK signals into camera control functions. These comprise the FLINK receiver (modified ARW 17 drone receiver), the FLINK Conversion Unit (FCU) and the Automatic-Manual Box (AMB).

FLINK CONVERSION UNIT (FCU): Unit which converts received READY, START, TIMING and CATALOG signals into control functions and adds interval timing and synching when AMB is on AUTOMATIC. When AMB is on MANUAL the FCU operates as a fighter synch unit, furnishing READY, START and TIMING functions for studies involving only a fighter.

GSAP DRIVE UNIT: A camera motor with provision for driving two GSAP cameras by means of flexible shafts.

Mk III: A synchronizing and camera control system incorporating several improvements over the previous Mk II, having, in particular, a more accurate time standard, operation at 20 frames per second, indication of the instant of maximum shutter opening, and provision for flash photography of dials.

Mk IV: In function and action similar to the Mk III, but with manual monitoring substituted for the chain ground protective circuit of the Mk III, giving a smaller and hence portable SU.

OSCILLOGRAPH RECORDER (OR): A galvanometer type recorder containing twelve independent channels on which timing marks and camera shutter contact pulses are registered to enable comparisons in time. The recording is done on photo-sensitive paper by a beam of light. The paper drive is synchronized with the camera motors.

PHASING: Adjusting the relative shutter position by slipping on its shaft the eccentric cam which actuates the motor contacts.

SHUTTER CONTACTS: Electrical contacts on a camera shutter through which the instant of maximum shutter opening is referred to the oscillograph recorder.

SYNCHRONIZING OR SYNCHING: The act of bringing a camera motor, electrically tied to the master motor, to the same speed as the master motor.

TIMING MARKS, FILM: Double dots on the film edge, indicating one-second intervals, for the purpose of matching film from the various cameras and oscillograph with respect to time.

TIMING MARKS, OSCILLOGRAPH FILM: Trace deflections similar to the cataloging marks but of shorter duration.

TUNING FORK INVERTER (TFI): An electrically driven tuning fork, giving a frequency standard accurate to one part in 10,000. The output is 110 volts at 60 cycles and is used for the master synchronous motor in the SU and the timing motor in the OR.

ABBREVIATIONS

AFU:	Auxiliary Flash Unit
AMB:	Automatic-Manual Box
AML:	Aerial Measurements Laboratory, Northwestern University
ET:	Electrical Technician
FCU:	Flink Conversion Unit
FFU:	Fighter Flash Unit
GCU:	Gyro Control Unit
MCO:	Master Control Operator
MCU:	Master Control Unit
MFI:	Main Flash Inverter
MFU:	Main Flash Unit
Obs:	Observer
OCU:	Observer's Control Unit
OR:	Oscillograph Recorder
SU:	Synchronizing and Camera Control Unit
TFI:	Tuning Fork Inverter

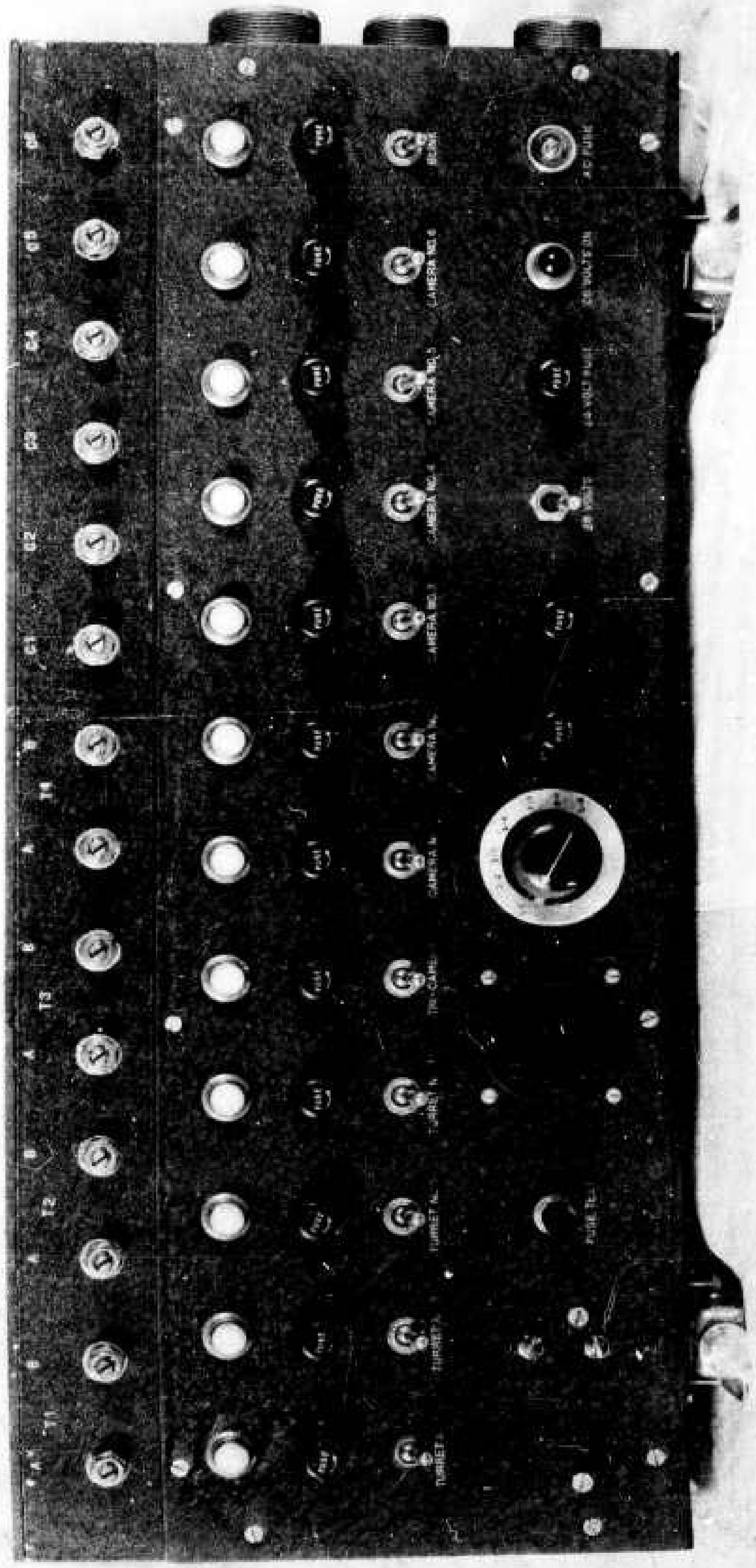

Fig. B_a-1.01. Synch Unit (SU) Mk III.

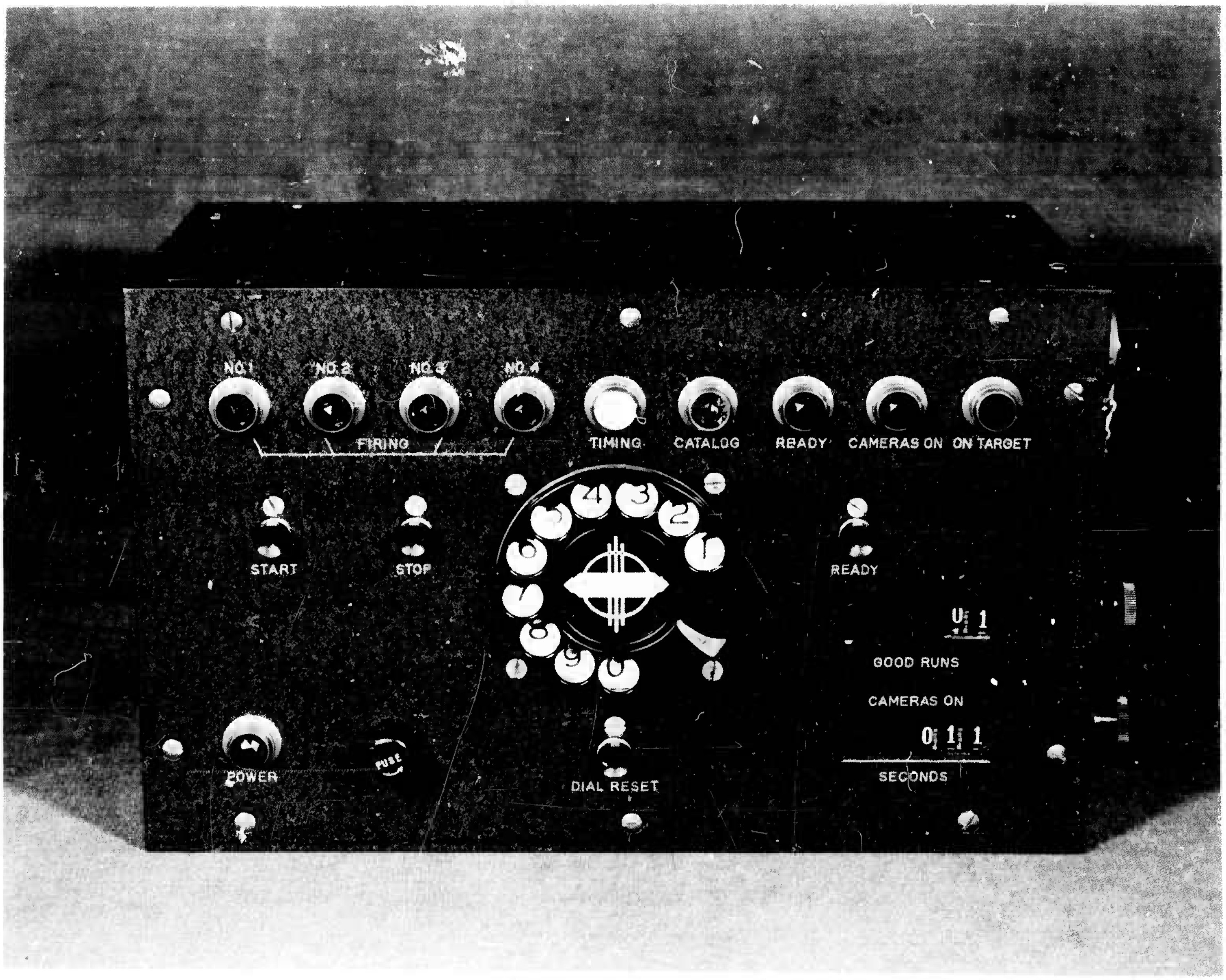

Fig. B_a-1.02. Master Control Unit (MCU) Mk III.

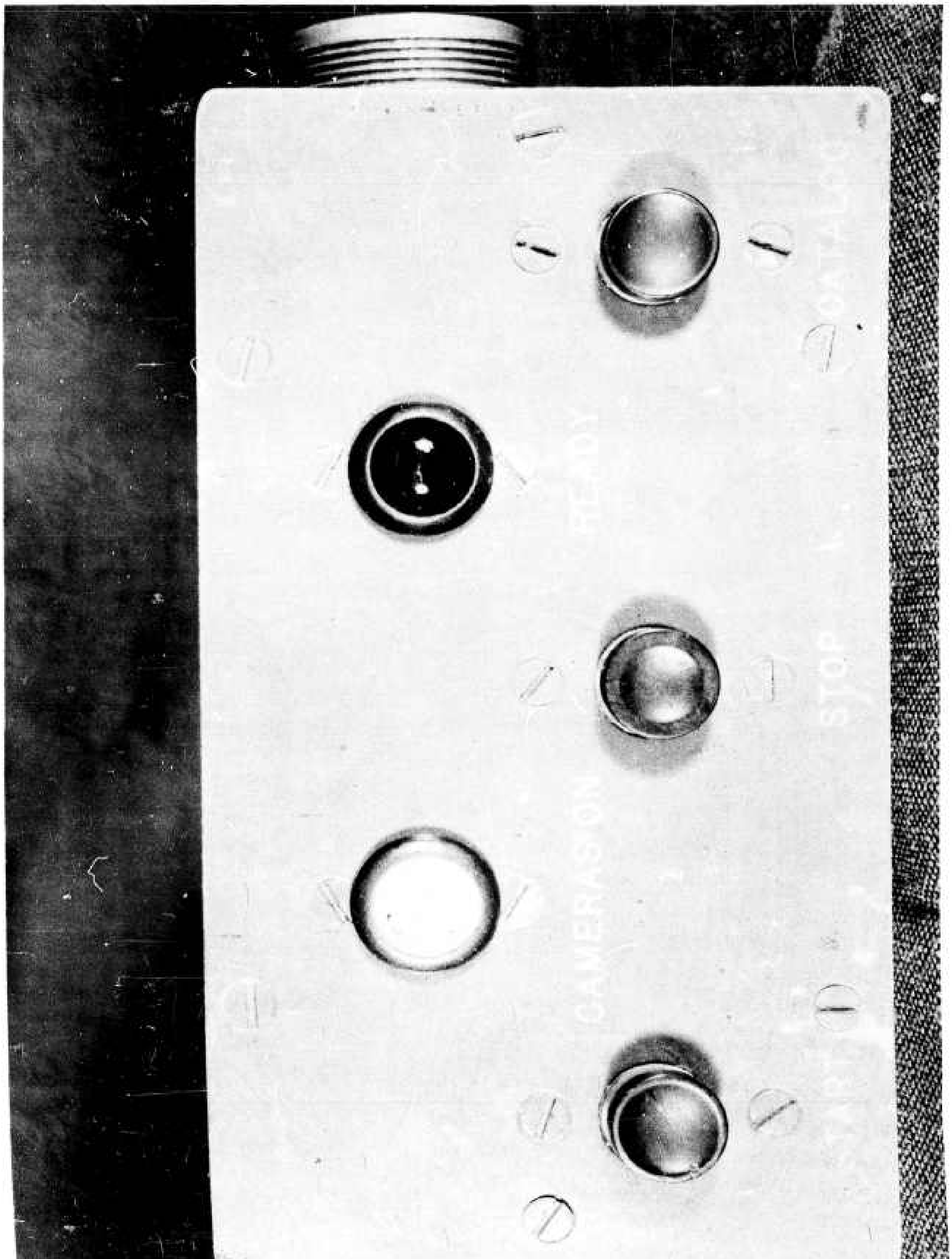

Fig. B_a-1.03. Observer's Control Unit (OCU), Mk III and Mk IV.

Fig. B_a-1.04. Gyro Control Unit (GCU).

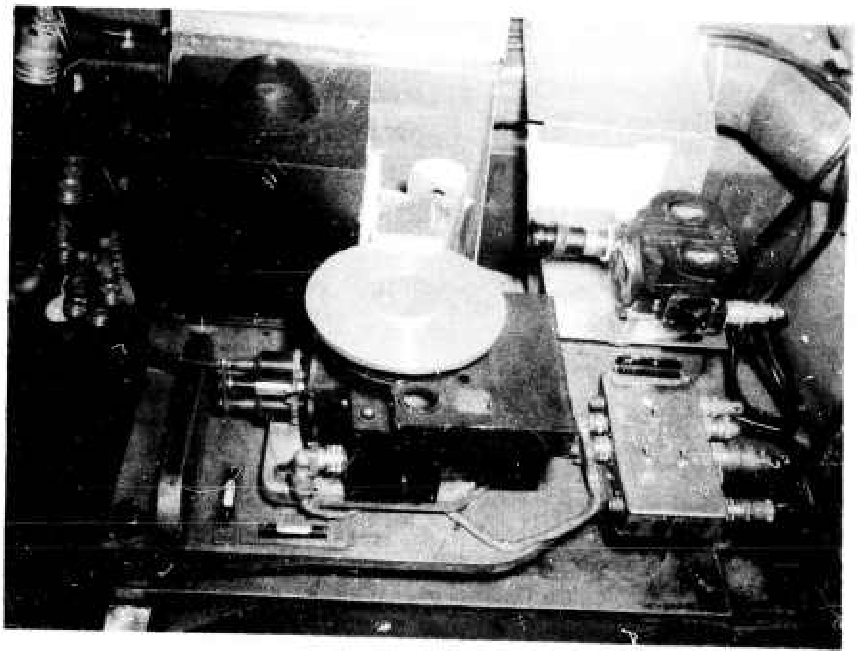

Fig. B_a-1.05. Gyro installation in PB4Y-2, AT 24.

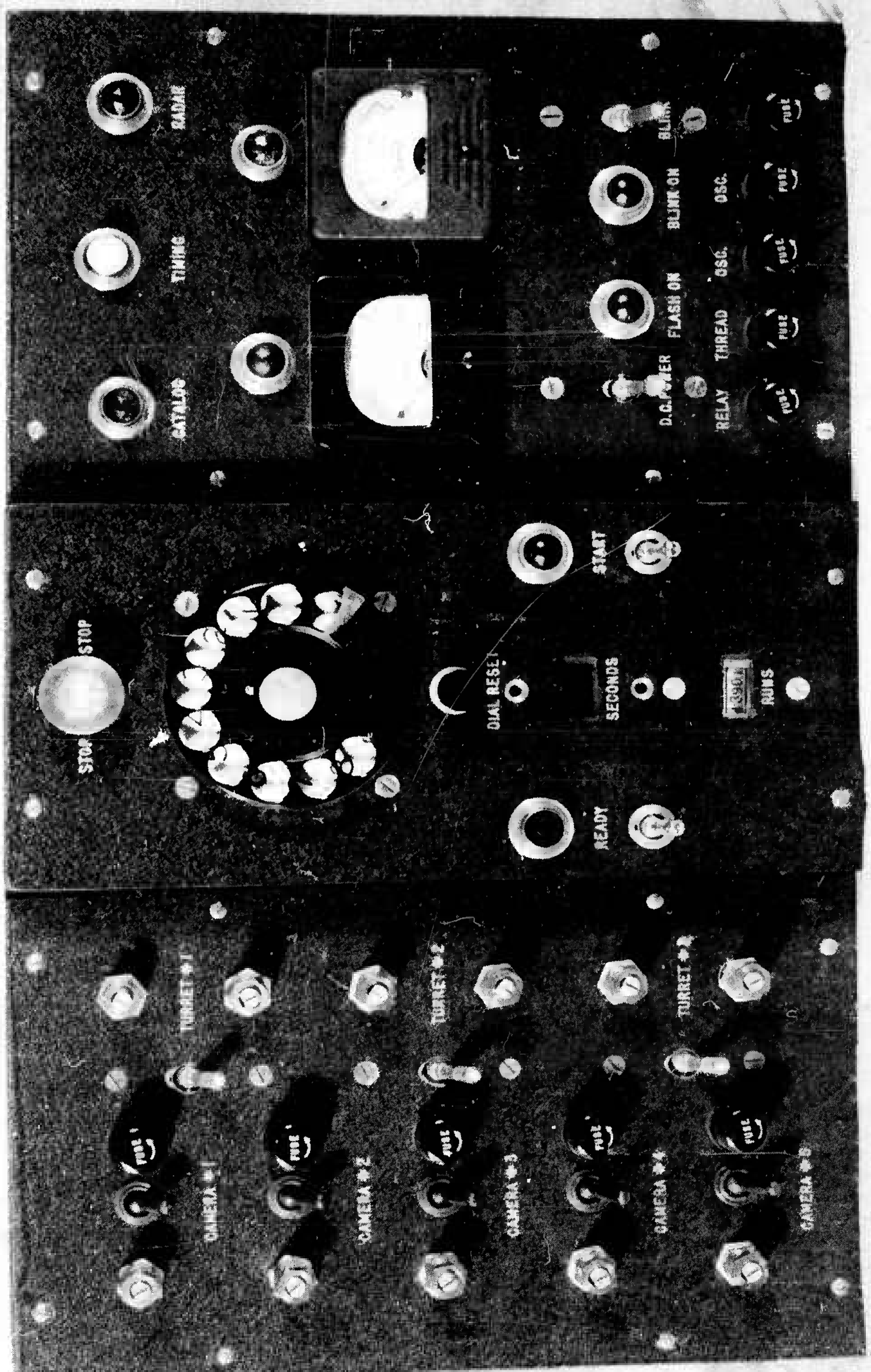

Fig. B_a-I.06. Synch and Master Control Unit, Mk IV.

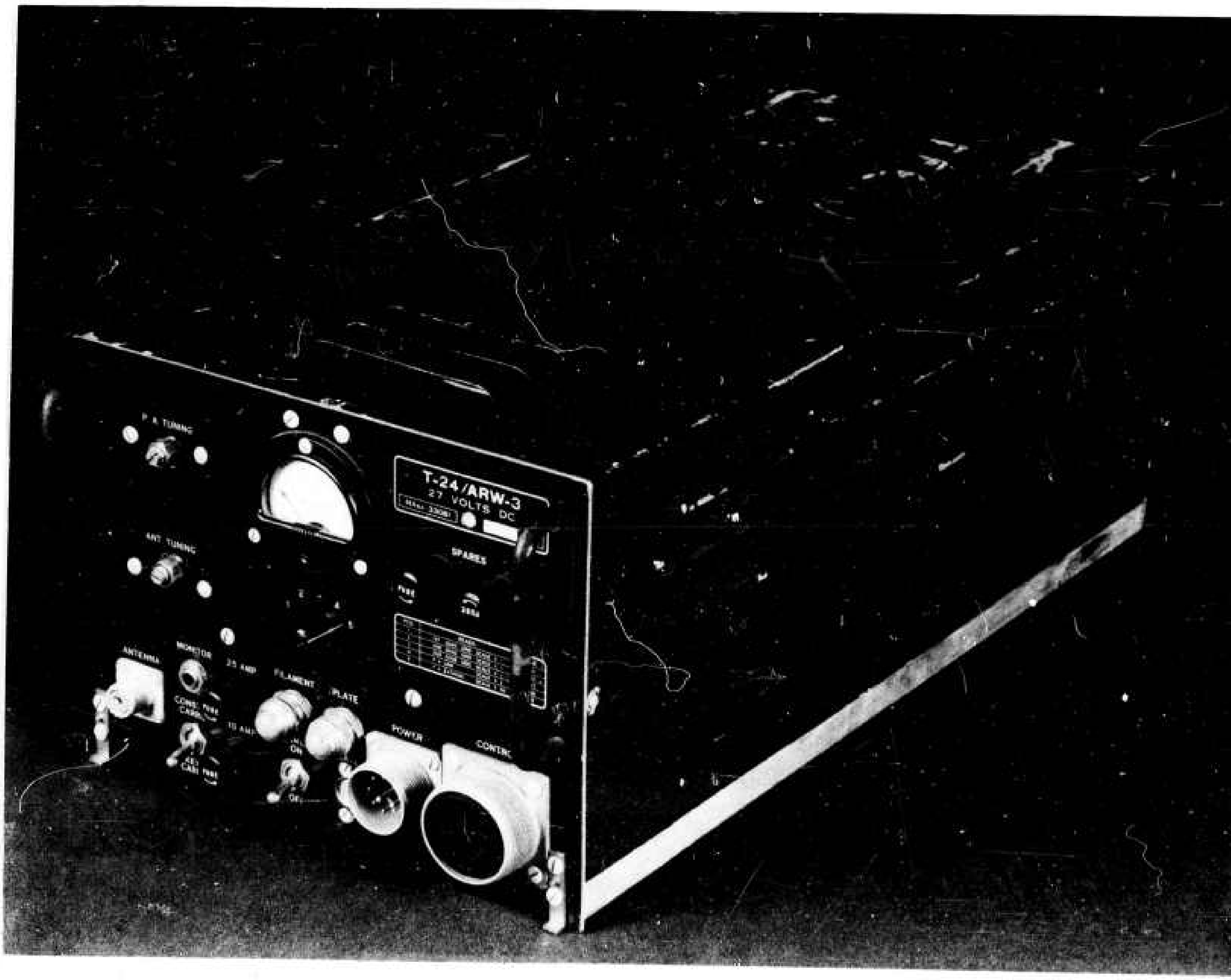

Fig. B_a-1.07. BLINK transmitter, Mk III and Mk IV.

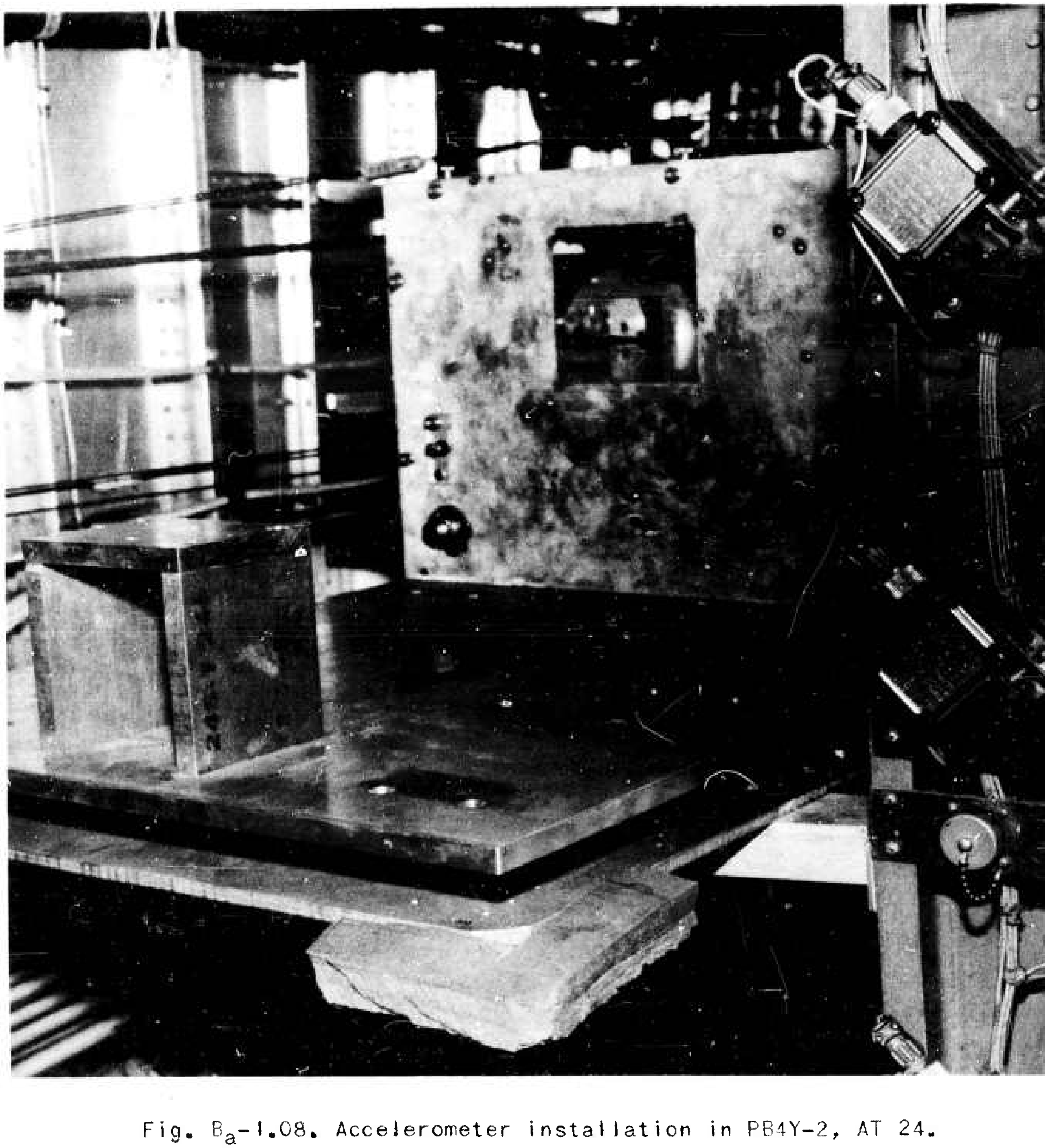

Fig. B_a-1.08. Accelerometer installation in PB4Y-2, AT 24.

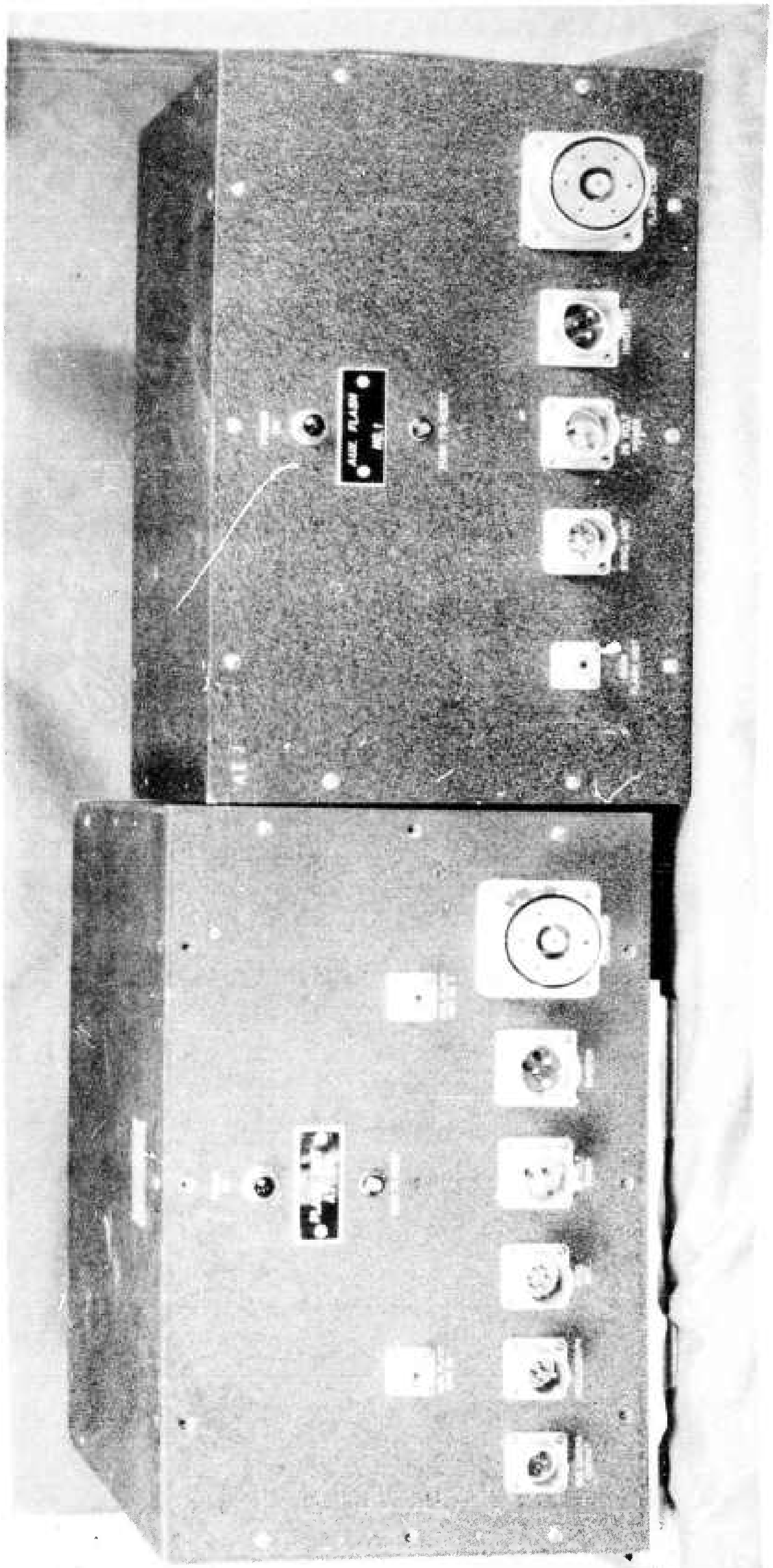

Fig. B_a-1.09. Main Flash Unit (MFU) and Auxiliary Flash Unit (AFU).

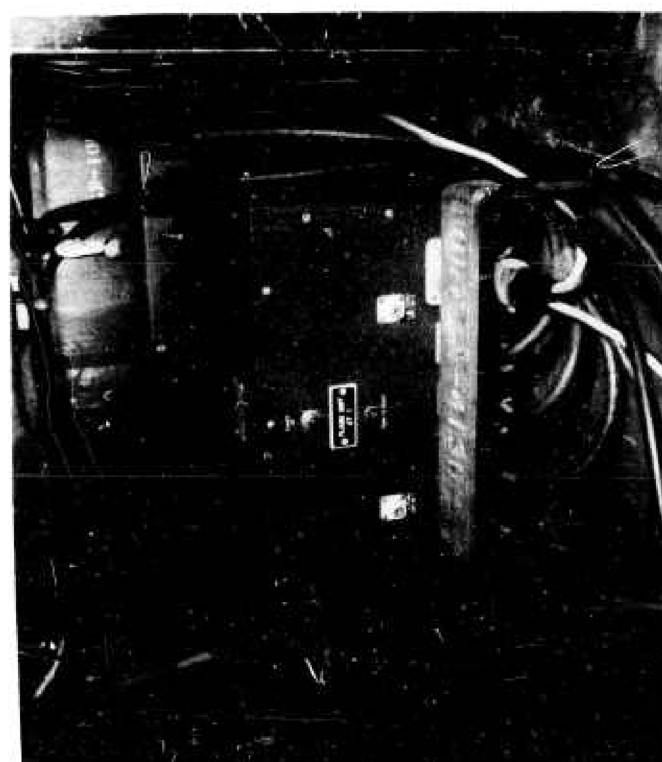

Fig. B_a-1.10. Main Flash Unit installation in PB4Y-2, AT 24.

Fig. B_a-I.II. Tuning Fork Inverter (TFI), Mk III and Mk IV.

Fig. B_a-2.01. Camera control equipment in PB4Y-2, AT 24.

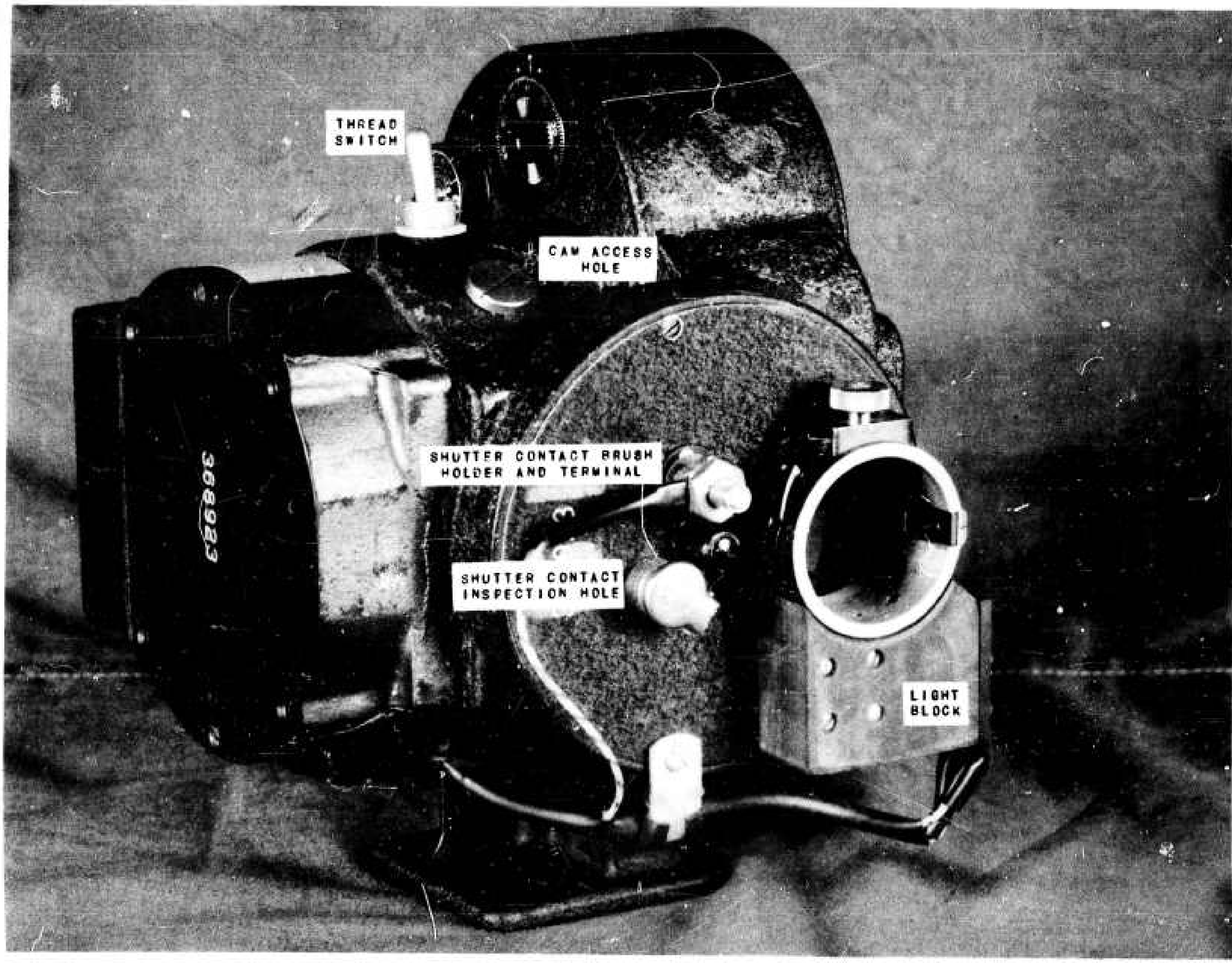

Fig. B_a-2.02. Bell and Howell A4, 35-mm camera (modified).

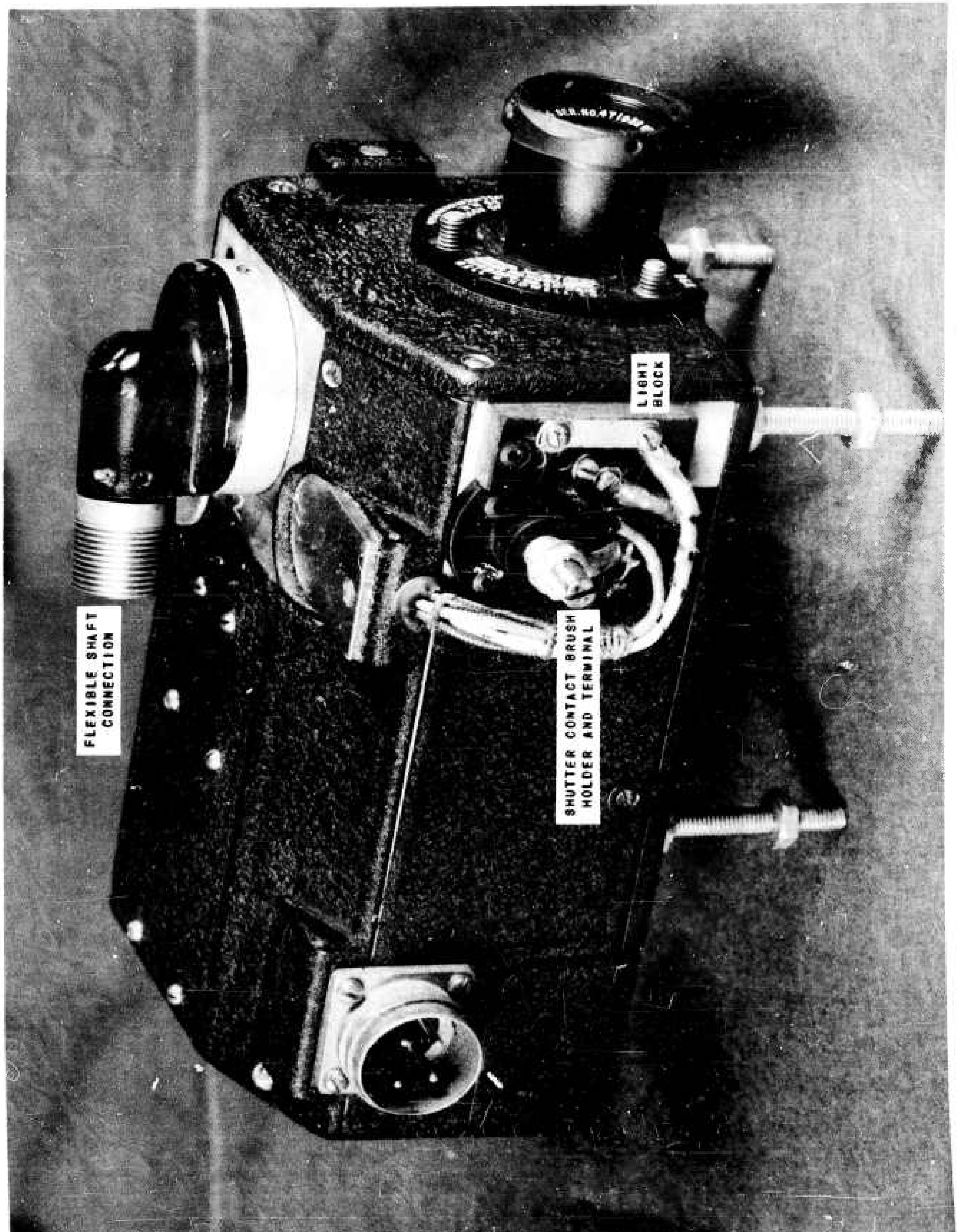

Fig. B_a-2.03. GSAP 16-mm camera (modified).

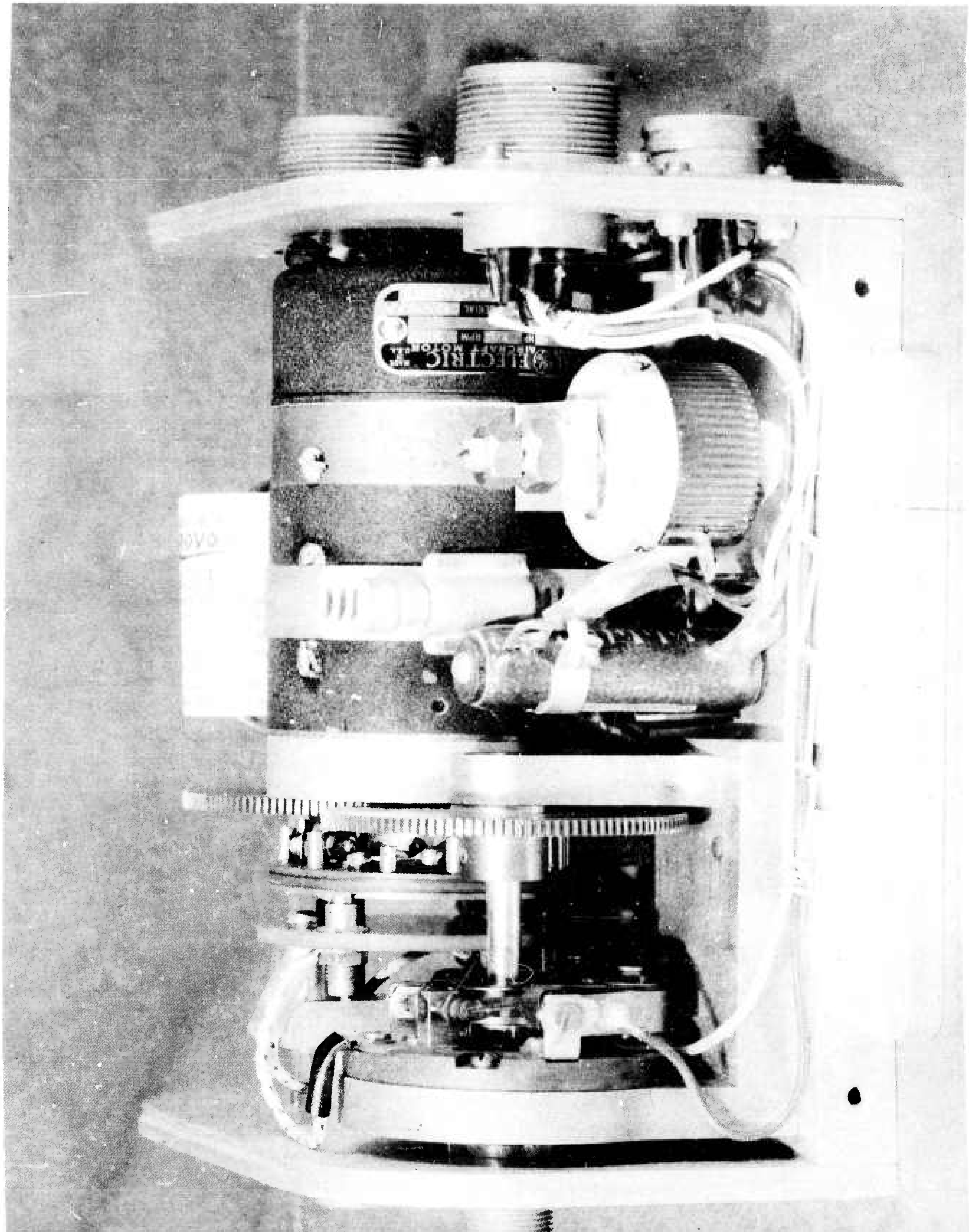

Fig. B_a-2.04. Gearbox and motor for GSAP camera drive.

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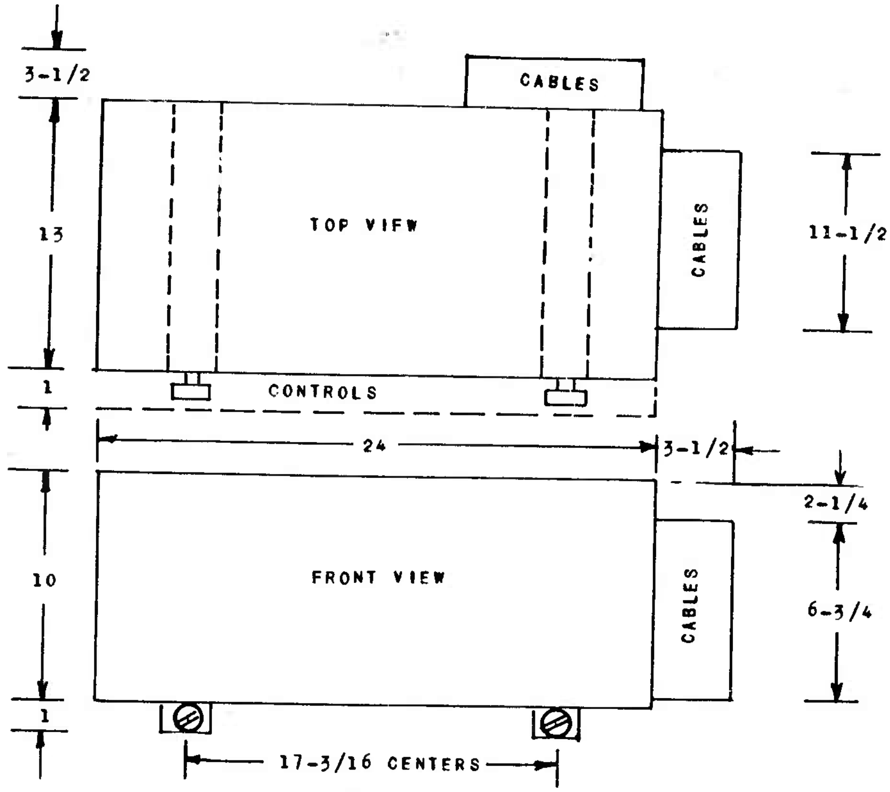

Fig. C_a-1.01. Clearance dimensions for SU.

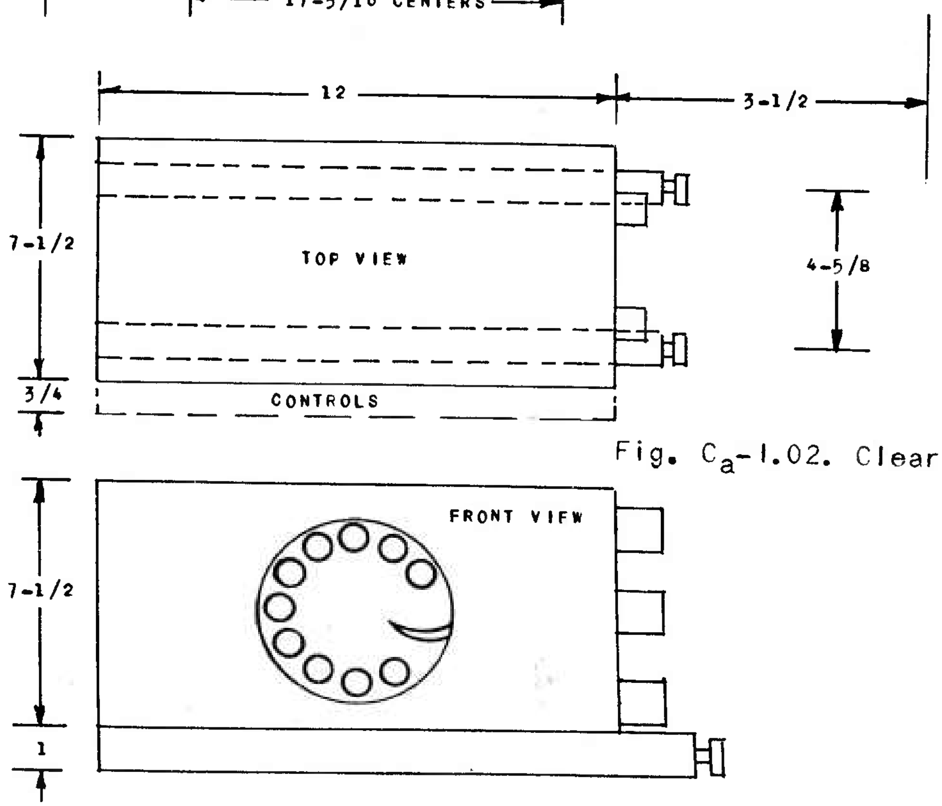

Fig. C_a-1.02. Clearance dimensions for MCU.

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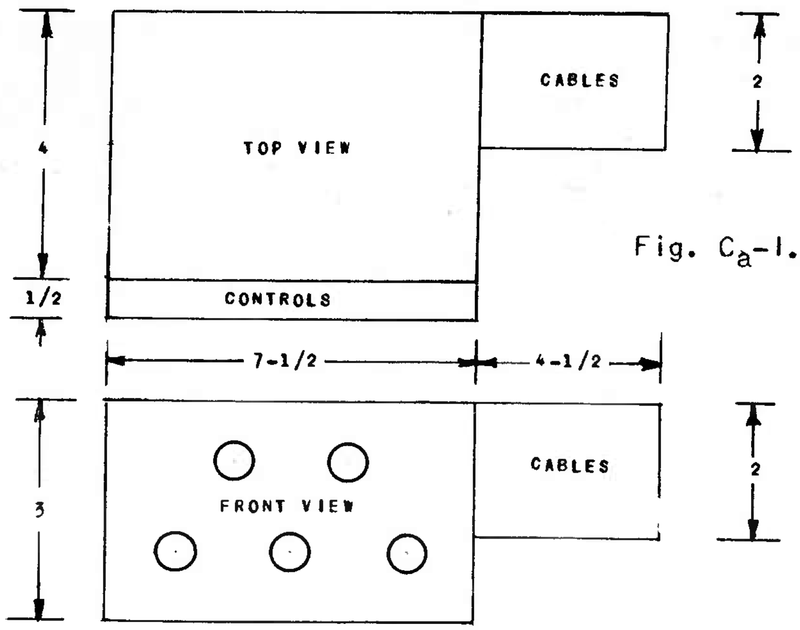

Fig. C_a-1.03. Clearance dimensions for OCU.

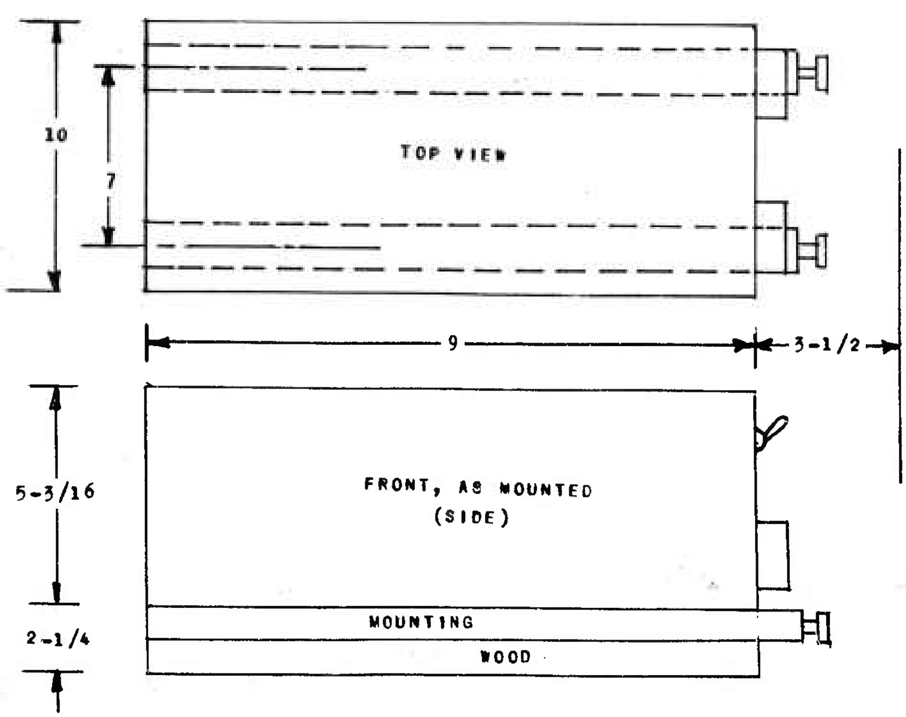

Fig. C_a-1.04. Clearance dimensions for TFI.

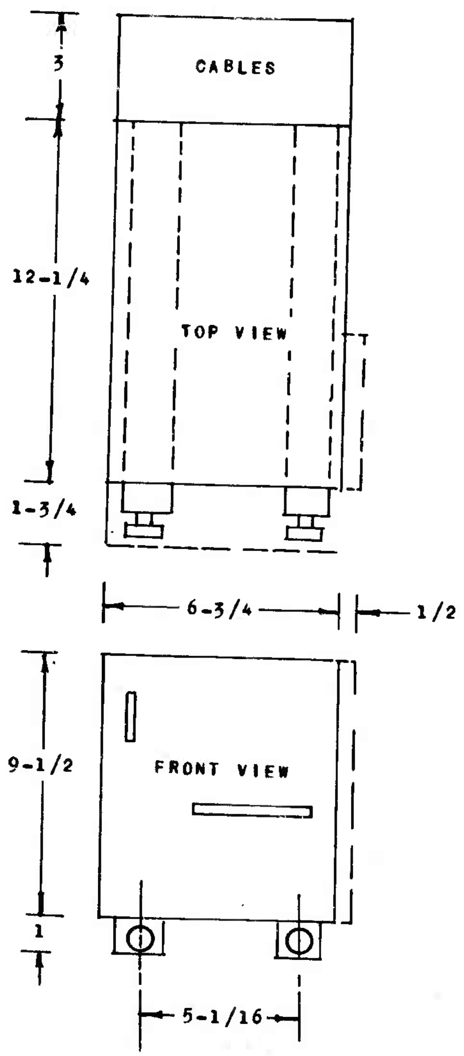

Fig. C_a-1.05. Clearance dimensions for OR (bomber, fighter).

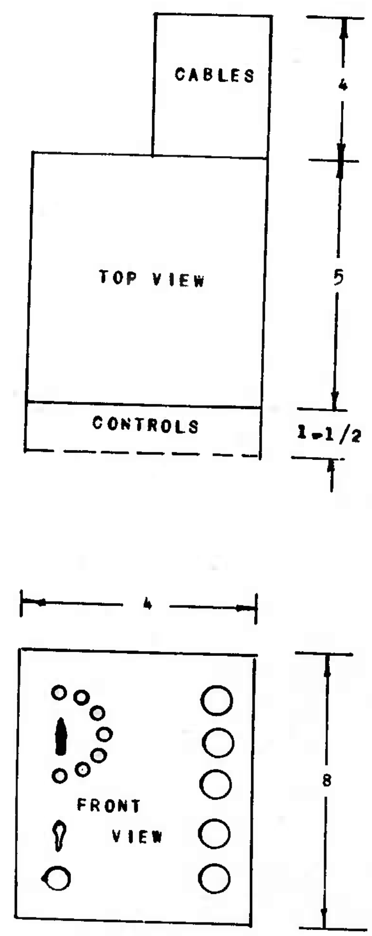

Fig. C_a-1.06. Clearance dimensions for GCU.

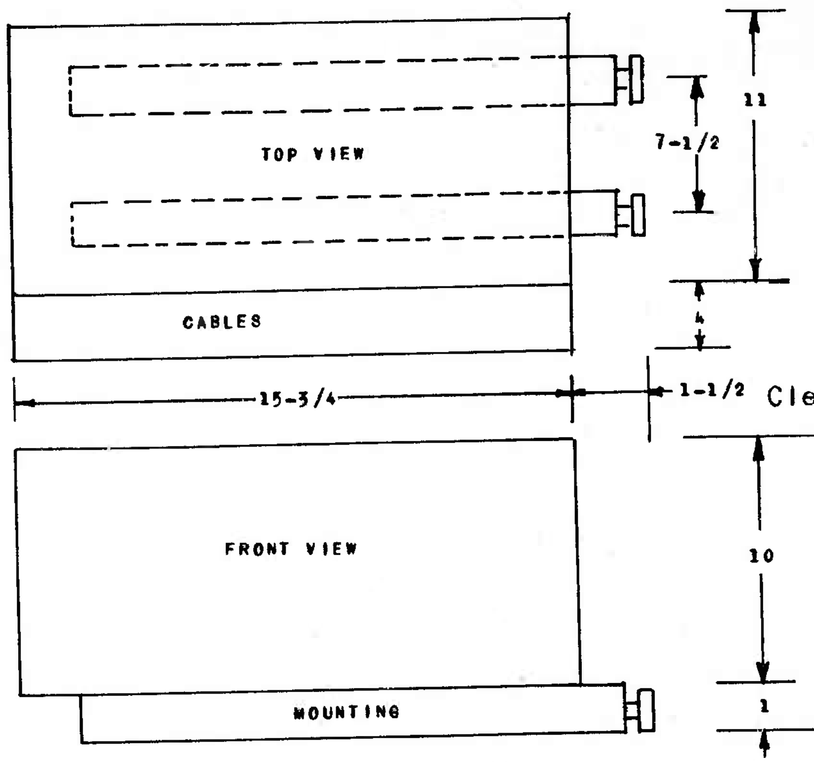

Fig. C_a-1.07.
Clearance dimensions for MFU.

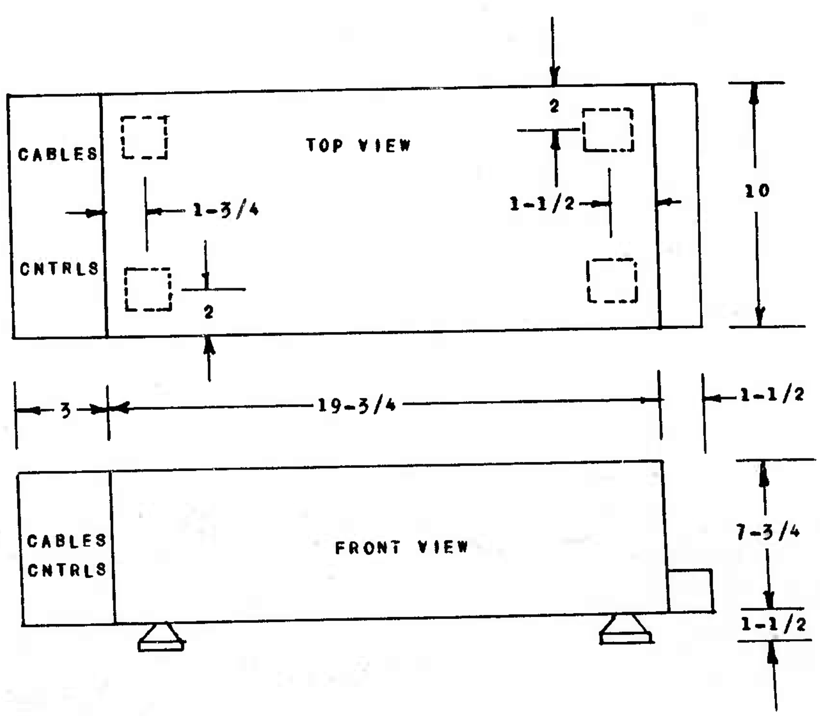

Fig. C_a-1.08.
Clearance dimensions for BLINK transmitter.

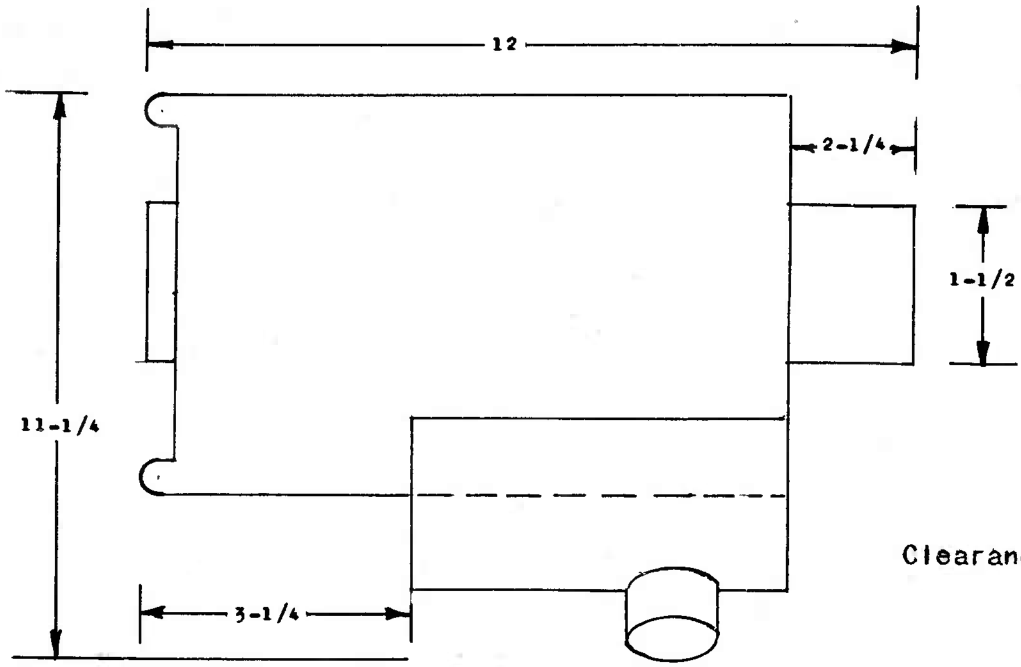

Fig. C_a-1.09.
Clearance dimensions for MR1.

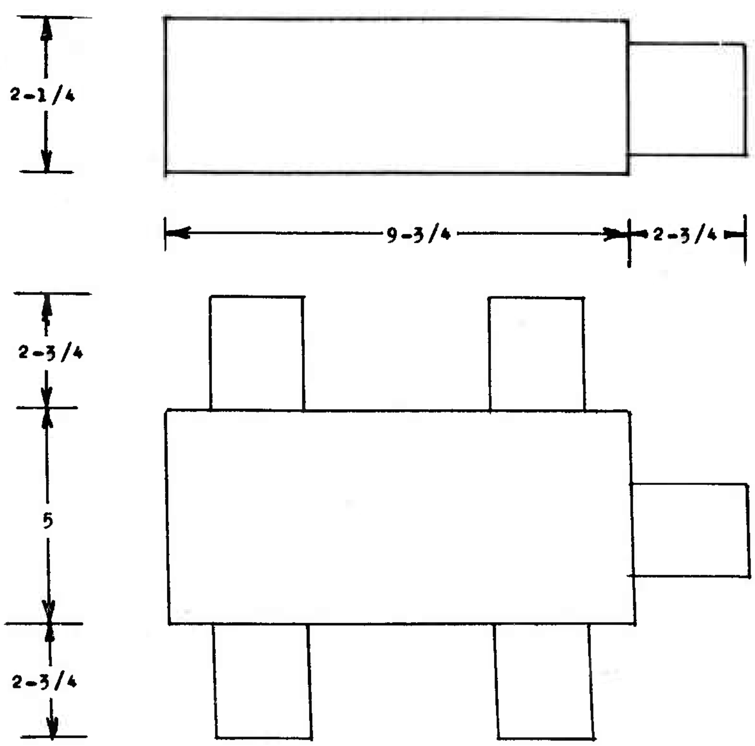

Fig. C_a-1.10. Clearance dimensions for Observer's junction box.

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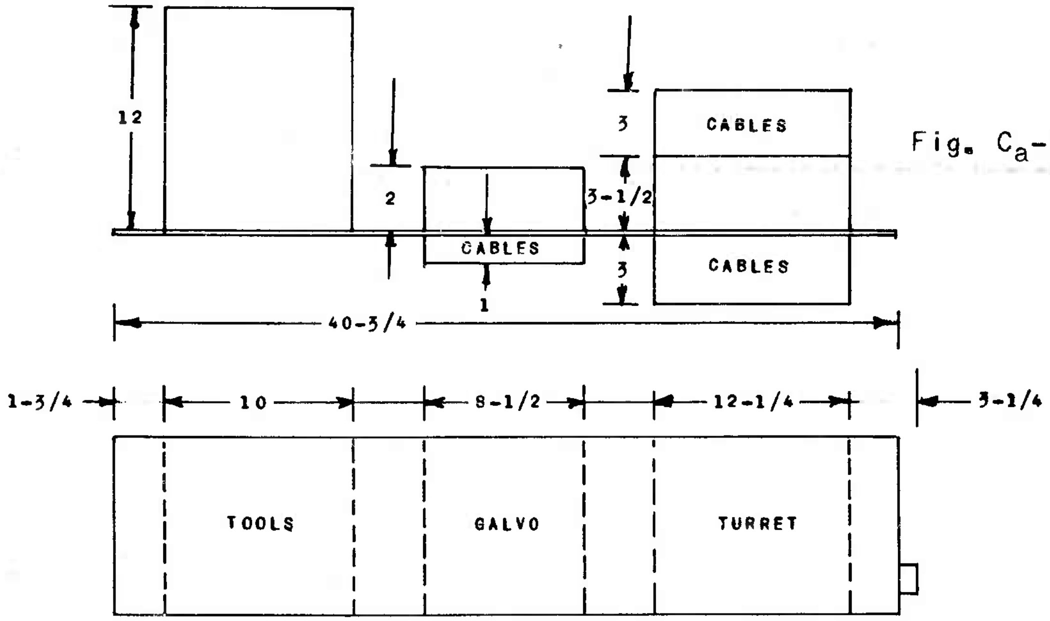

Fig. C_a-1.11. Clearance dimensions for patch panels.

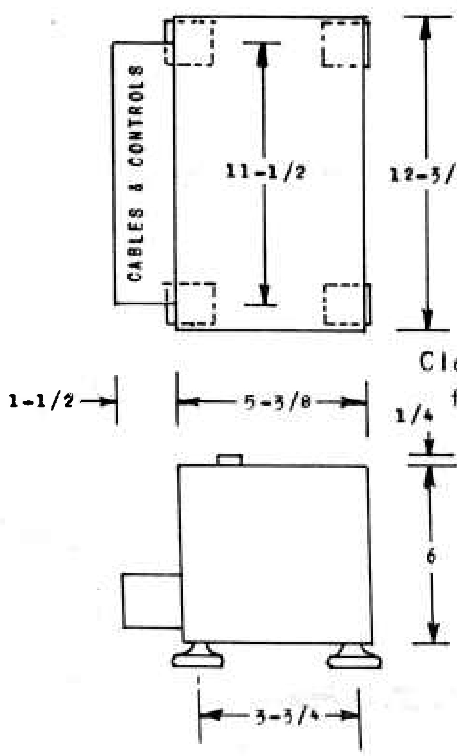

Fig. C_a-1.12. Clearance dimensions for wire-recorder.

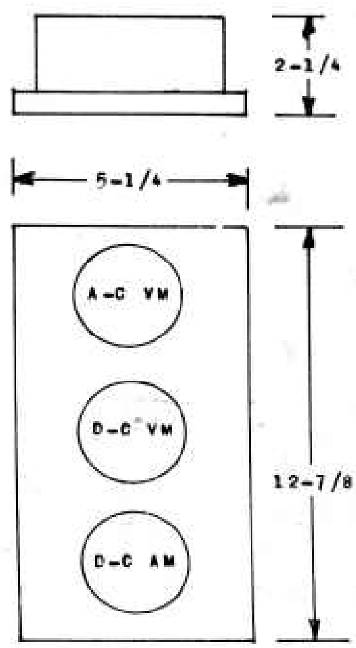

Fig. C_a-1.13. Clearance dimensions for meter panel.

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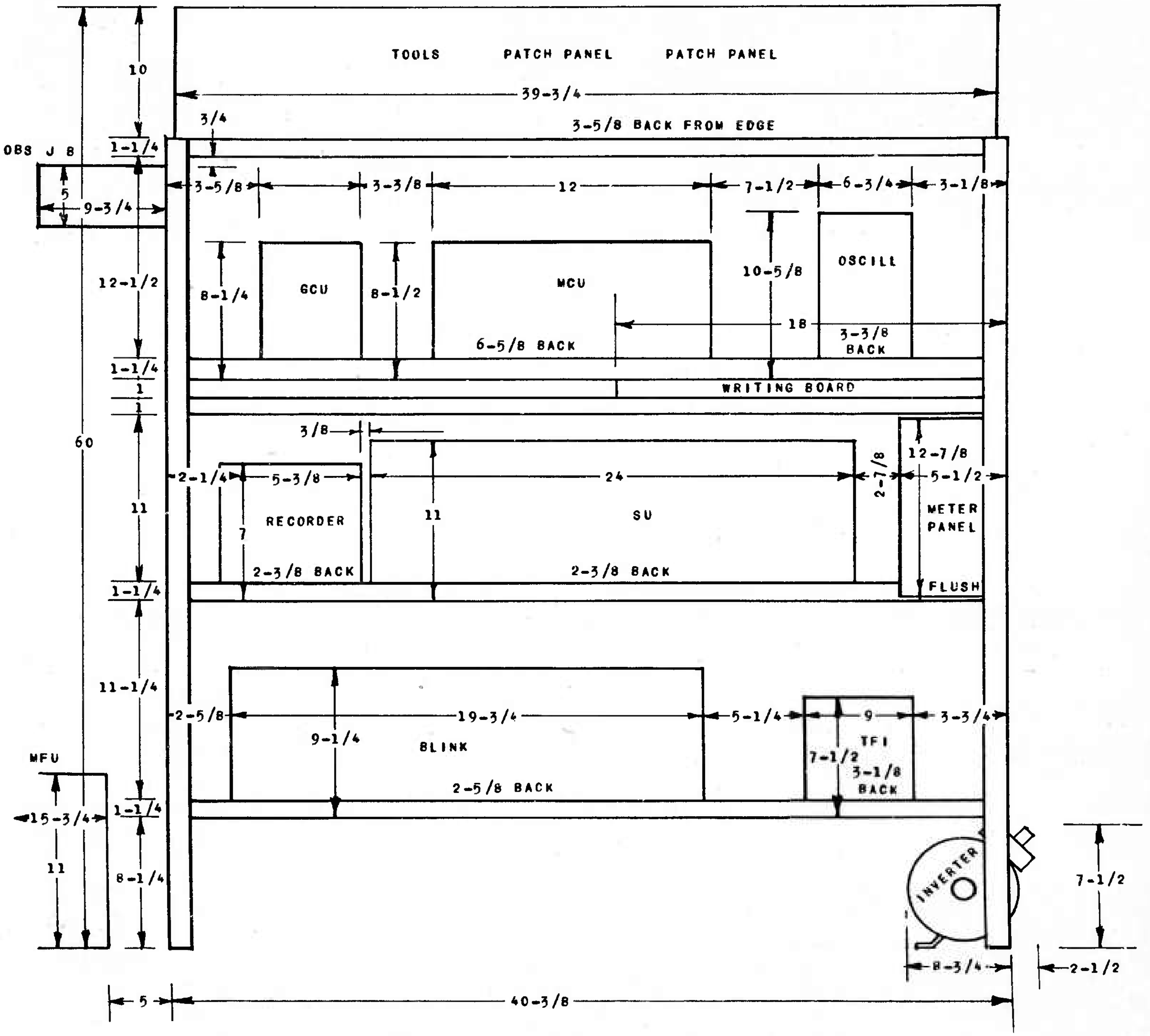


Fig. C_a-1.14. Dimensions for starboard rack, PB4Y-2.

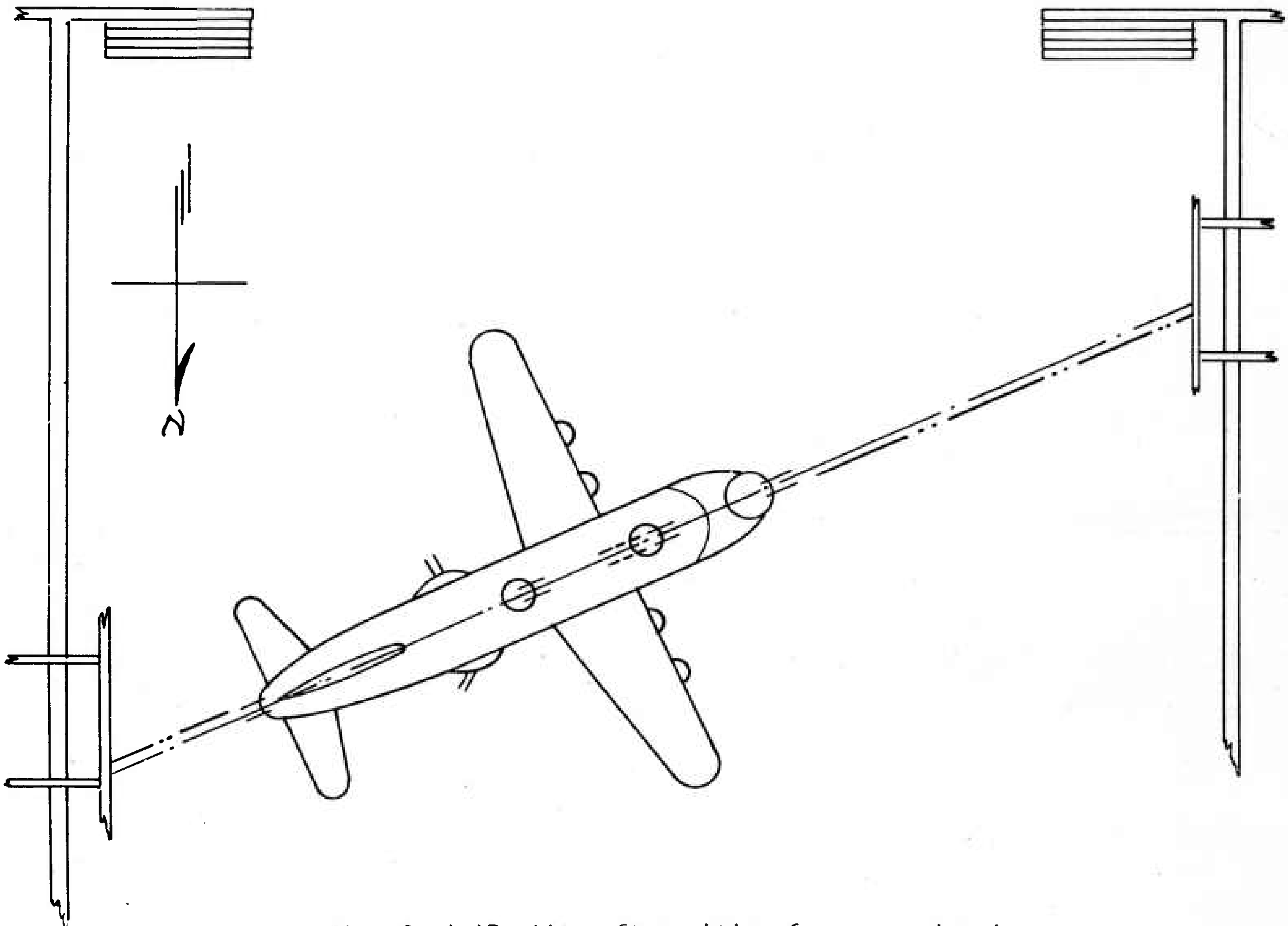
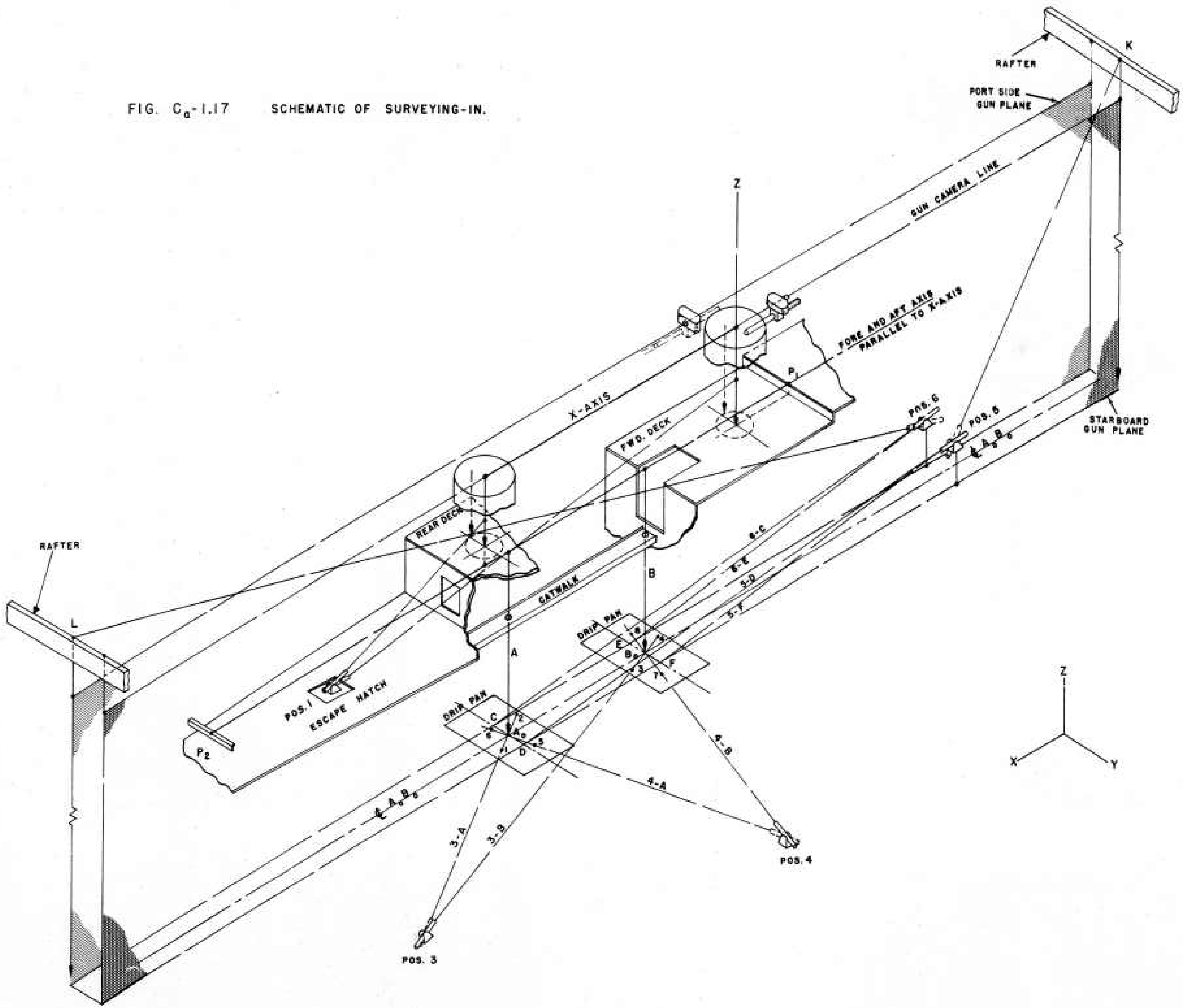


Fig. C_a-1.15. Aircraft position for surveying-in.

FIG. C_a-1.17 SCHEMATIC OF SURVEYING-IN.



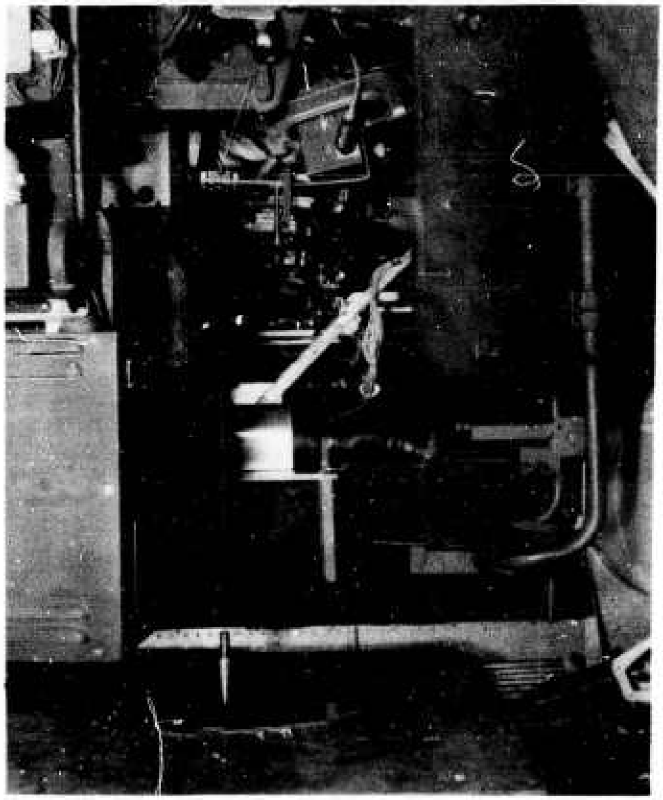


Fig. C_a-1.16. Plumbline from turret.

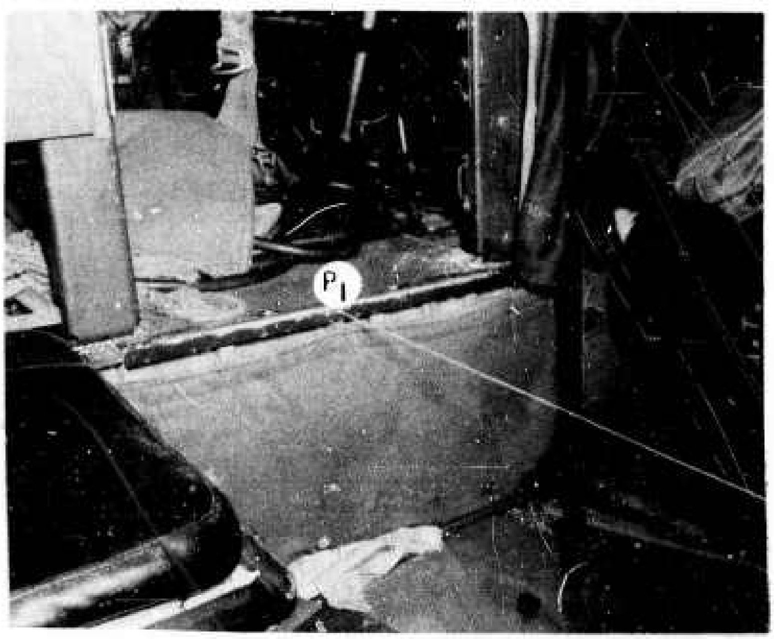


Fig. C_a-1.18.
Point P_1 at pilot's compartment.

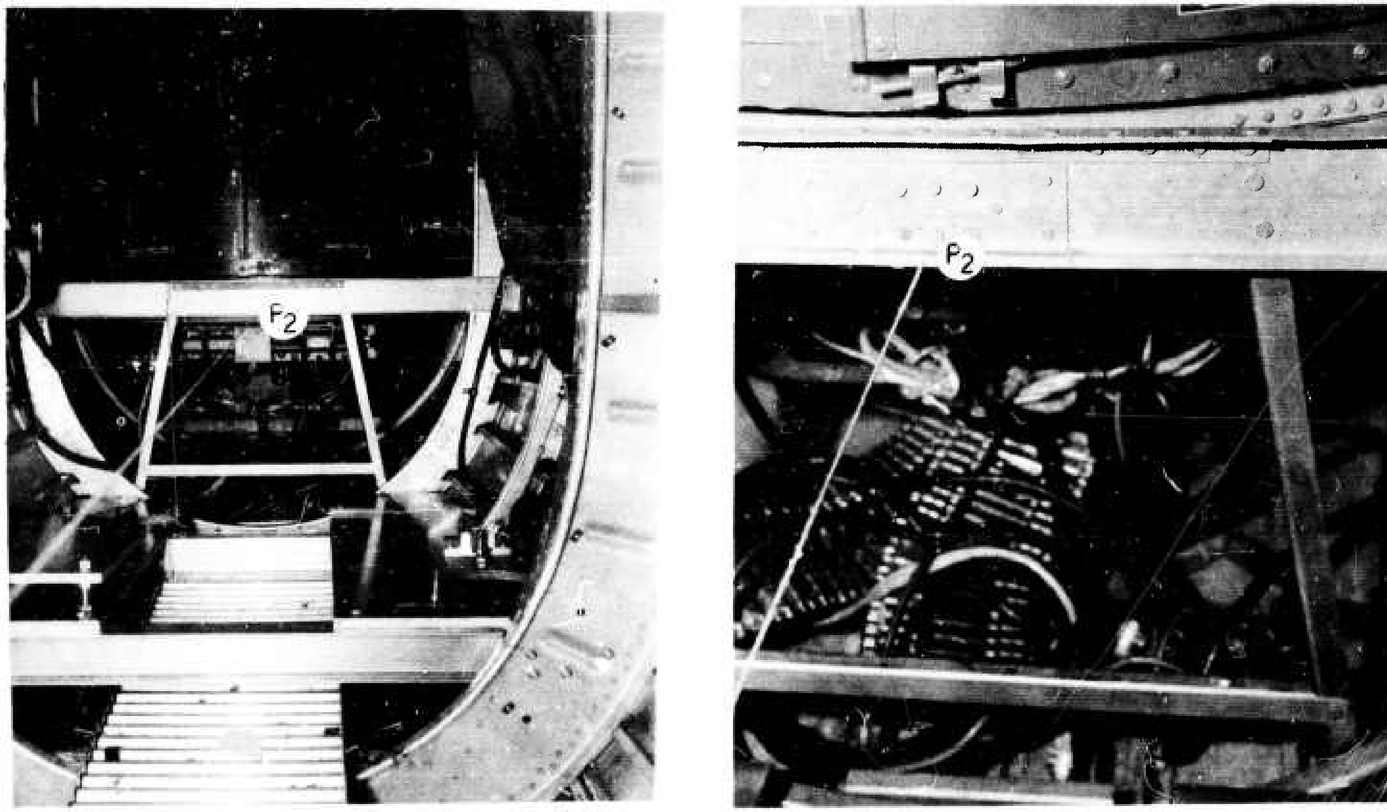


Fig. C_a-1.19. Point P_2 at tail turret.

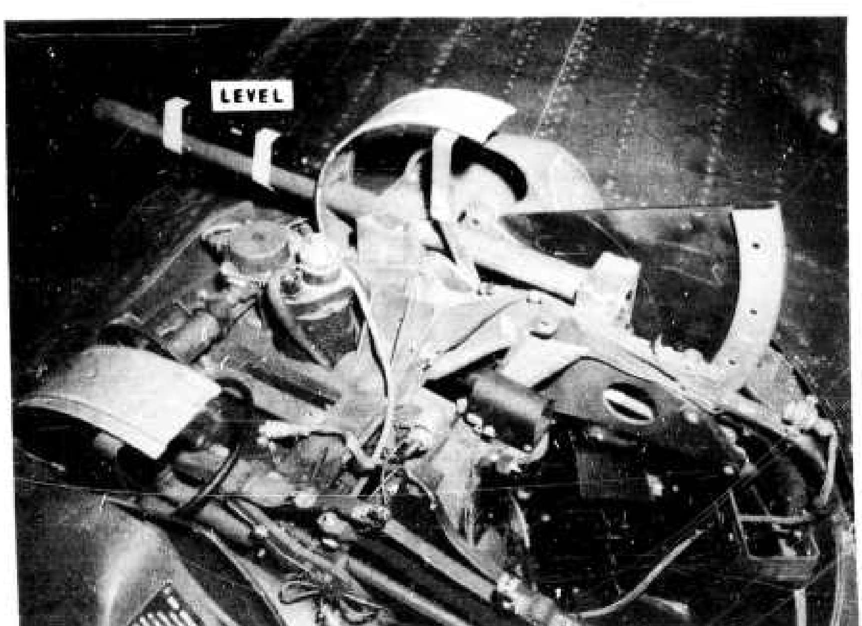


Fig. C_a-1.20. Gun leveling.

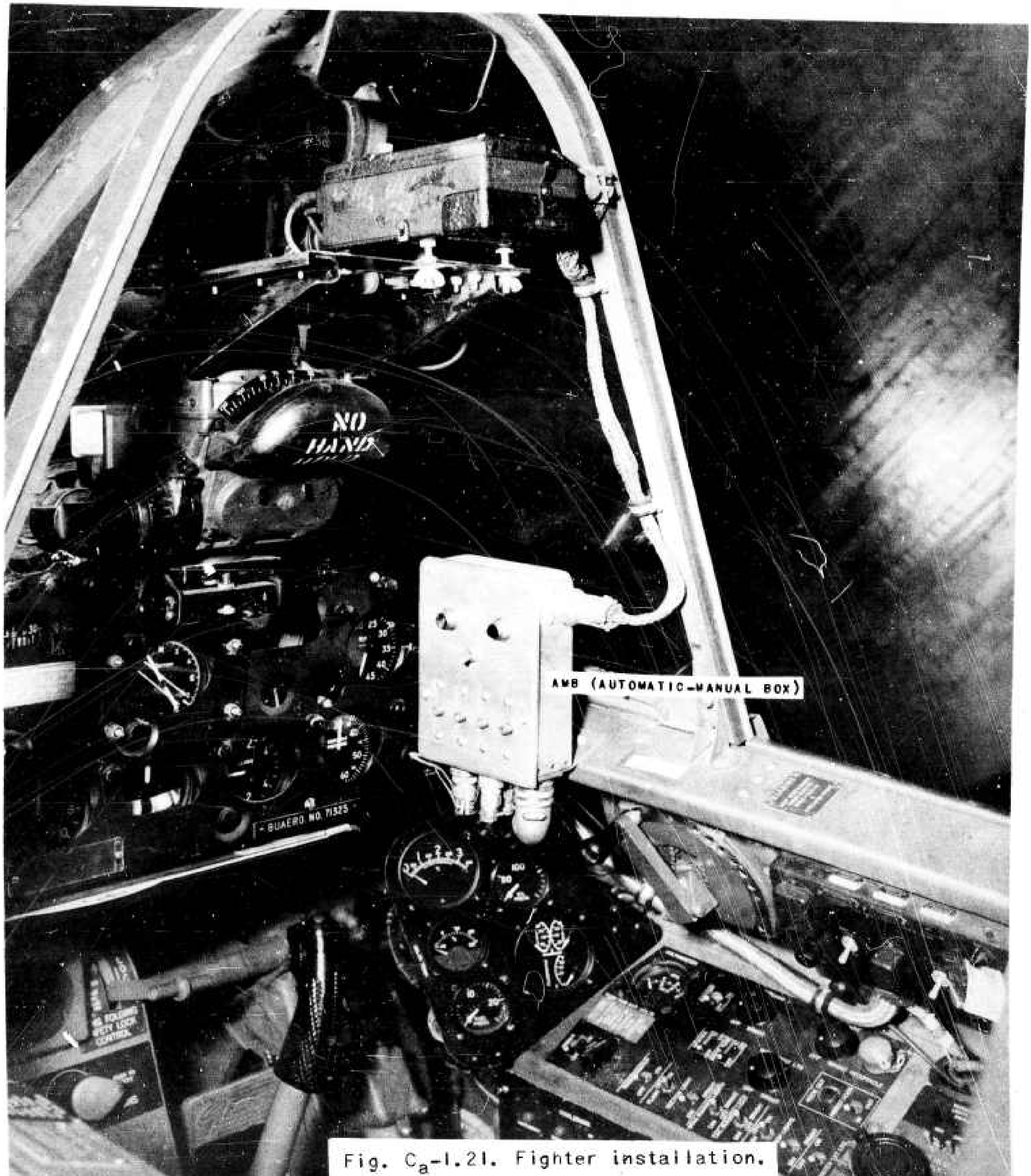


Fig. C_a-1.21. Fighter installation.

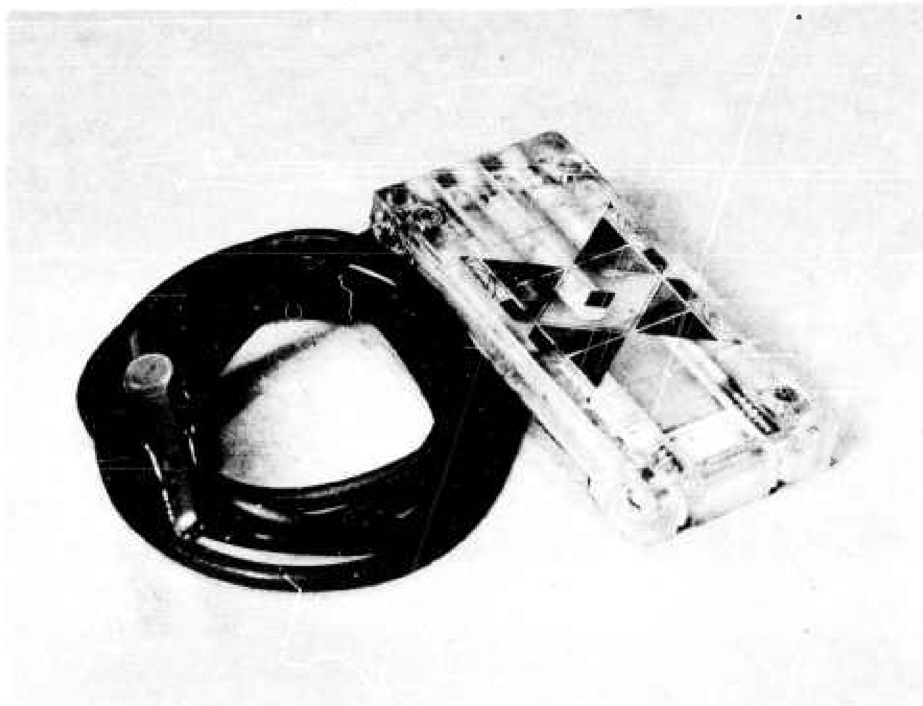
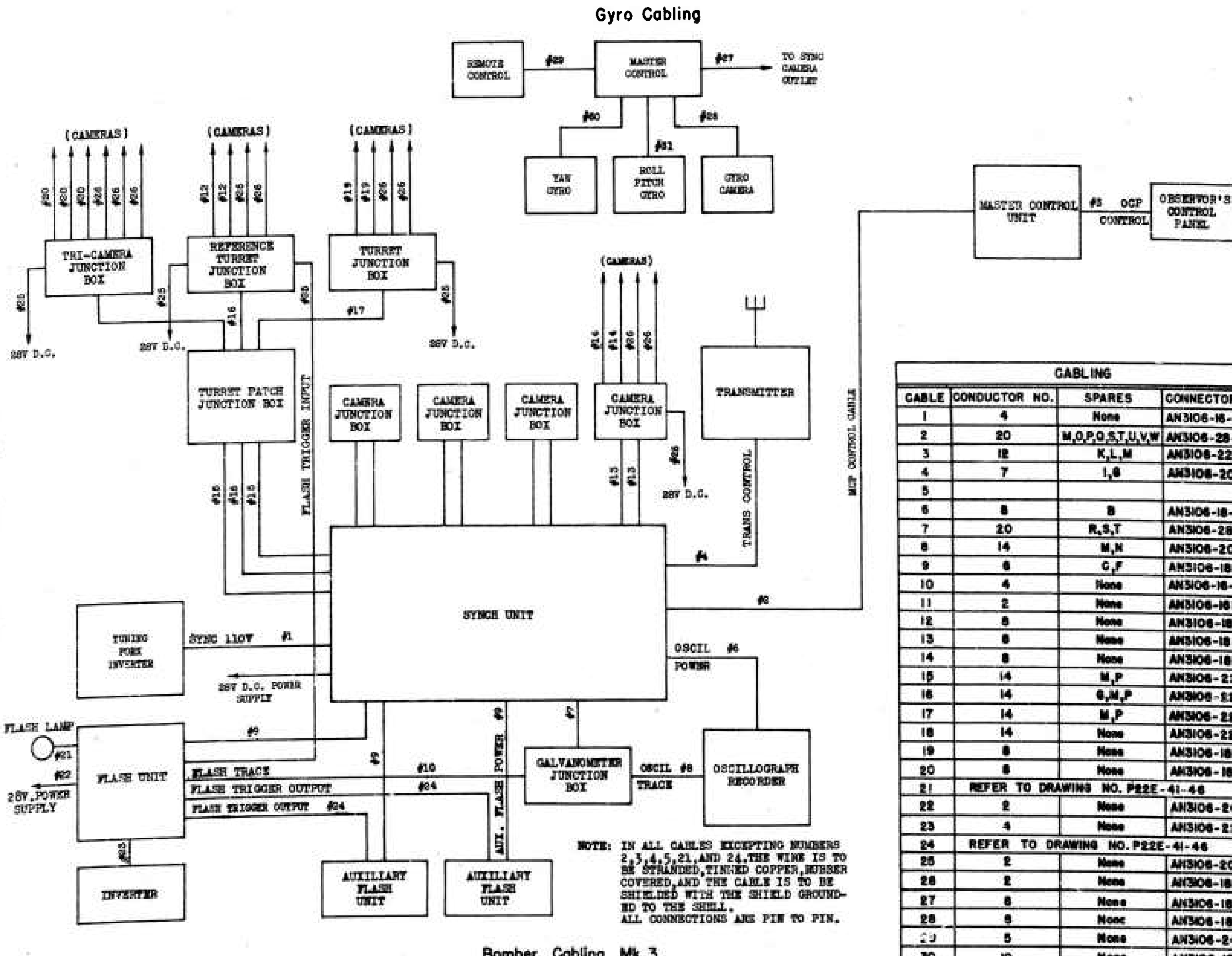


Fig. C_a-1.22. Focusing device for A4 camera.

Fig. C_a-1.23. Focusing device for GSAP camera.



CABLING

CABLE	CONDUCTOR NO.	SPARES	CONNECTOR NO.
1	4	None	AN3106-16-9S
2	20	M,O,P,Q,S,T,U,V,W	AN3106-28-16S
3	12	K,L,M	AN3106-22-19S
4	7	I,G	AN3106-20-16S
5			
6	8	B	AN3106-18-8S
7	20	R,S,T	AN3106-28-16S
8	14	M,N	AN3106-20-1S
9	6	C,F	AN3106-18-12S
10	4	None	AN3106-16-9S
11	2	None	AN3106-16S-4S
12	8	None	AN3106-18-8S
13	8	None	AN3106-18-8S
14	8	None	AN3106-18-8S
15	14	M,P	AN3106-22-19S
16	14	G,M,P	AN3106-22-19S
17	14	M,P	AN3106-22-19S
18	14	None	AN3106-22-19S
19	8	None	AN3106-18-8S
20	8	None	AN3106-18-8S
21	REFER TO DRAWING NO. P22E-41-46		
22	2	None	AN3106-20-23S
23	4	None	AN3106-22-4S
24	REFER TO DRAWING NO. P22E-41-46		
25	2	None	AN3106-20-23P
26	2	None	AN3106-18-3S
27	8	None	AN3106-18-8S
28	8	None	AN3106-18-8S
29	5	None	AN3106-24-5S
30	10	None	AN3106-18-1S
31	16	None	AN3106-14S-5S

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Fig. C_a-2.01. Bomber cabling diagram.

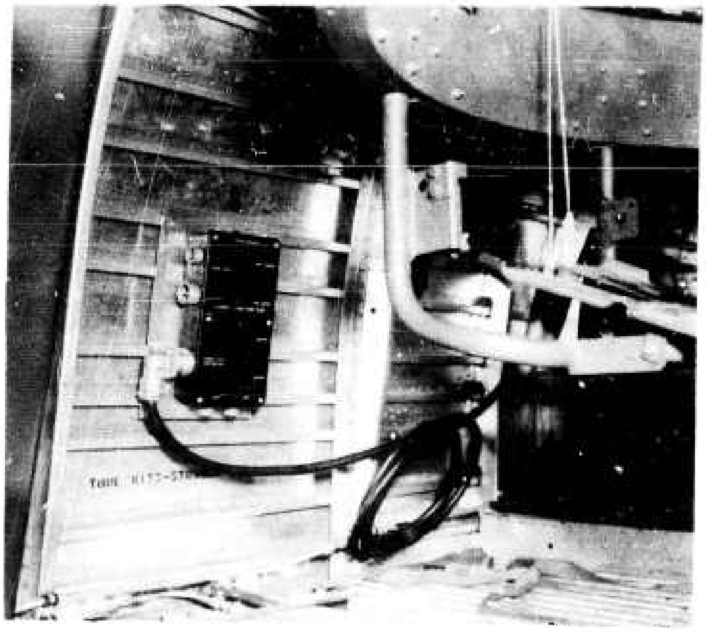


Fig. C_a-2.02. Turret junction box.

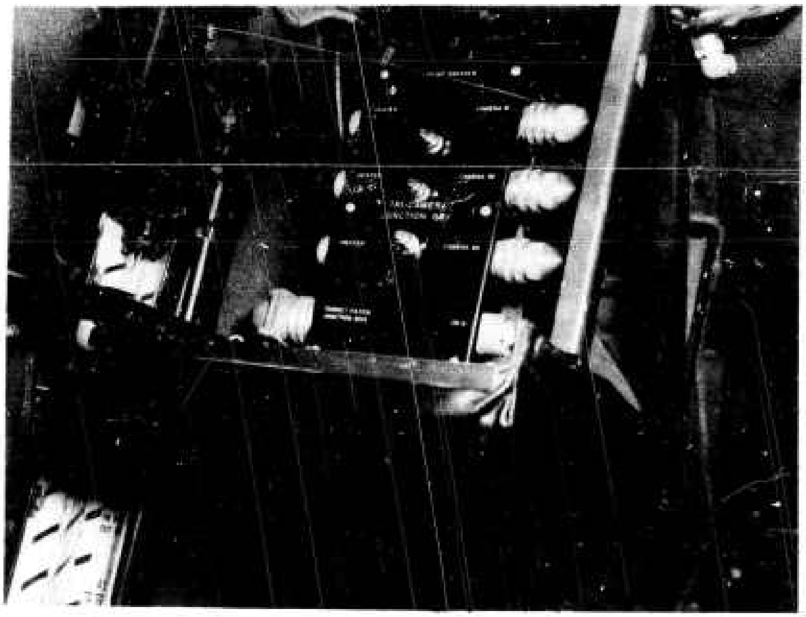


Fig. C_a-2.03. Tri-camera junction box.

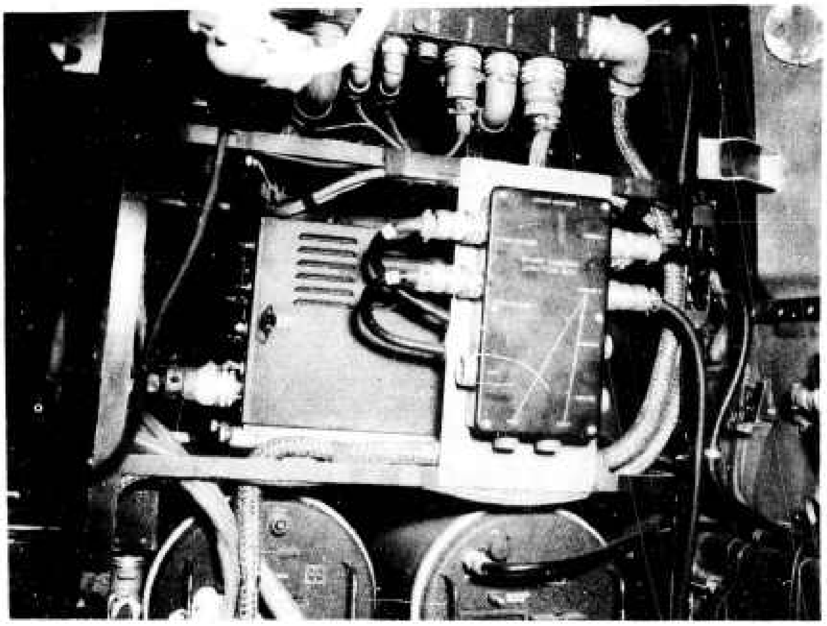
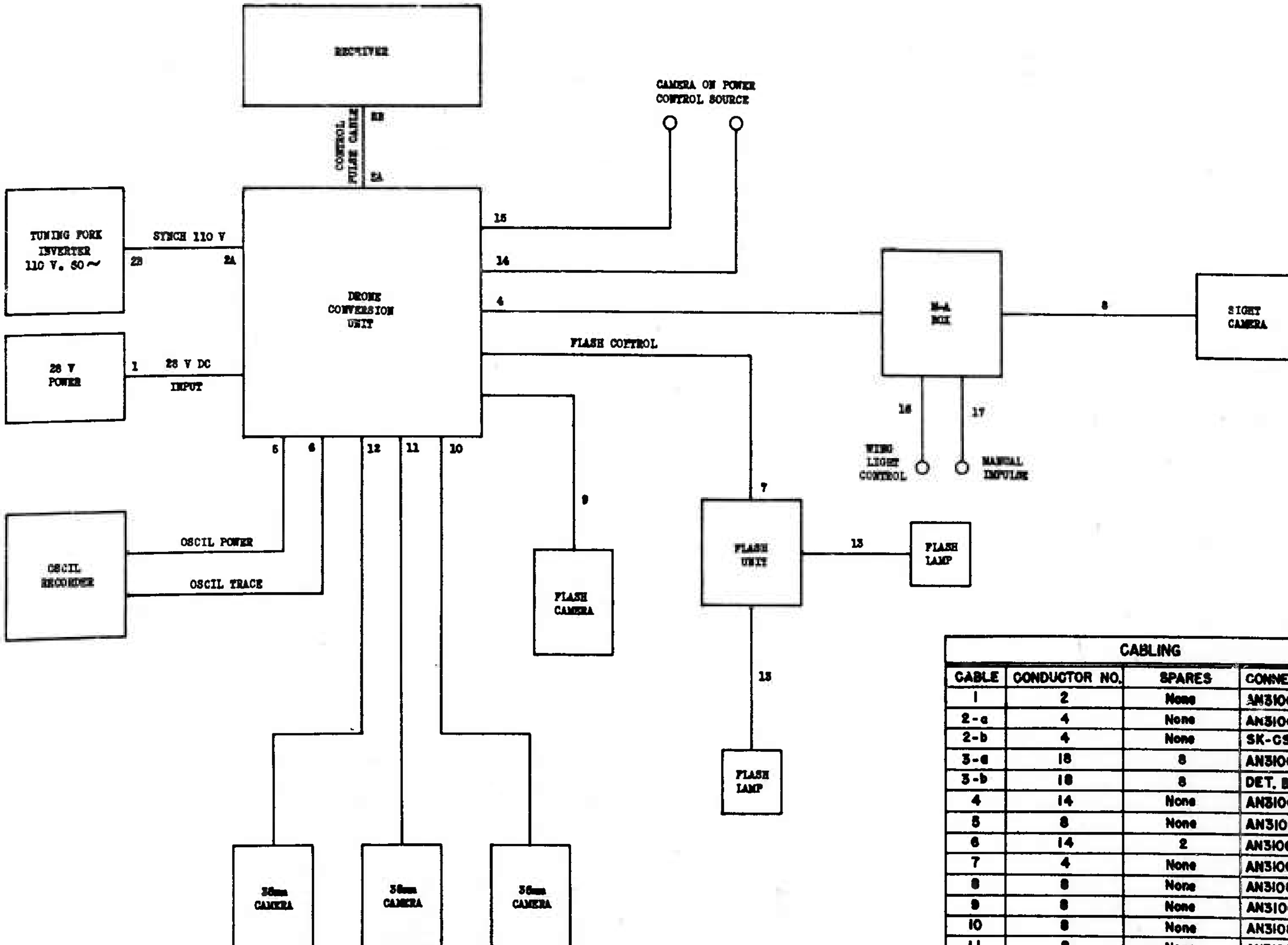


Fig. C_a-2.04. Spare camera junction box.



CABLING			
CABLE	CONDUCTOR NO.	SPARES	CONNEOTOR NO.
1	2	None	AN3106-20-23S
2-a	4	None	AN3106-16-9S
2-b	4	None	SK-CS-32SL
3-a	18	8	AN3106-22-19P
3-b	18	8	DET. B-52004
4	14	None	AN3106-20-1S
5	8	None	AN3108-18-8S
6	14	2	AN3106-20-1S
7	4	None	AN3106-14S-2P
8	8	None	AN3108-18-8S
9	8	None	AN3106-18-8S
10	8	None	AN3108-18-8S
11	8	None	AN3108-18-8S
12	8	None	AN3106-18-8S
13	3	None	AN3102-20-16S
14	REFER TO FLINK CONTROL SYSTEM CIRCUIT DIAGRAM		AN3102-14S-2S
15			AN3102-14S-2S
16	3	None	AN3106-18S-5P
17	1	1	AN3106-14S-9S

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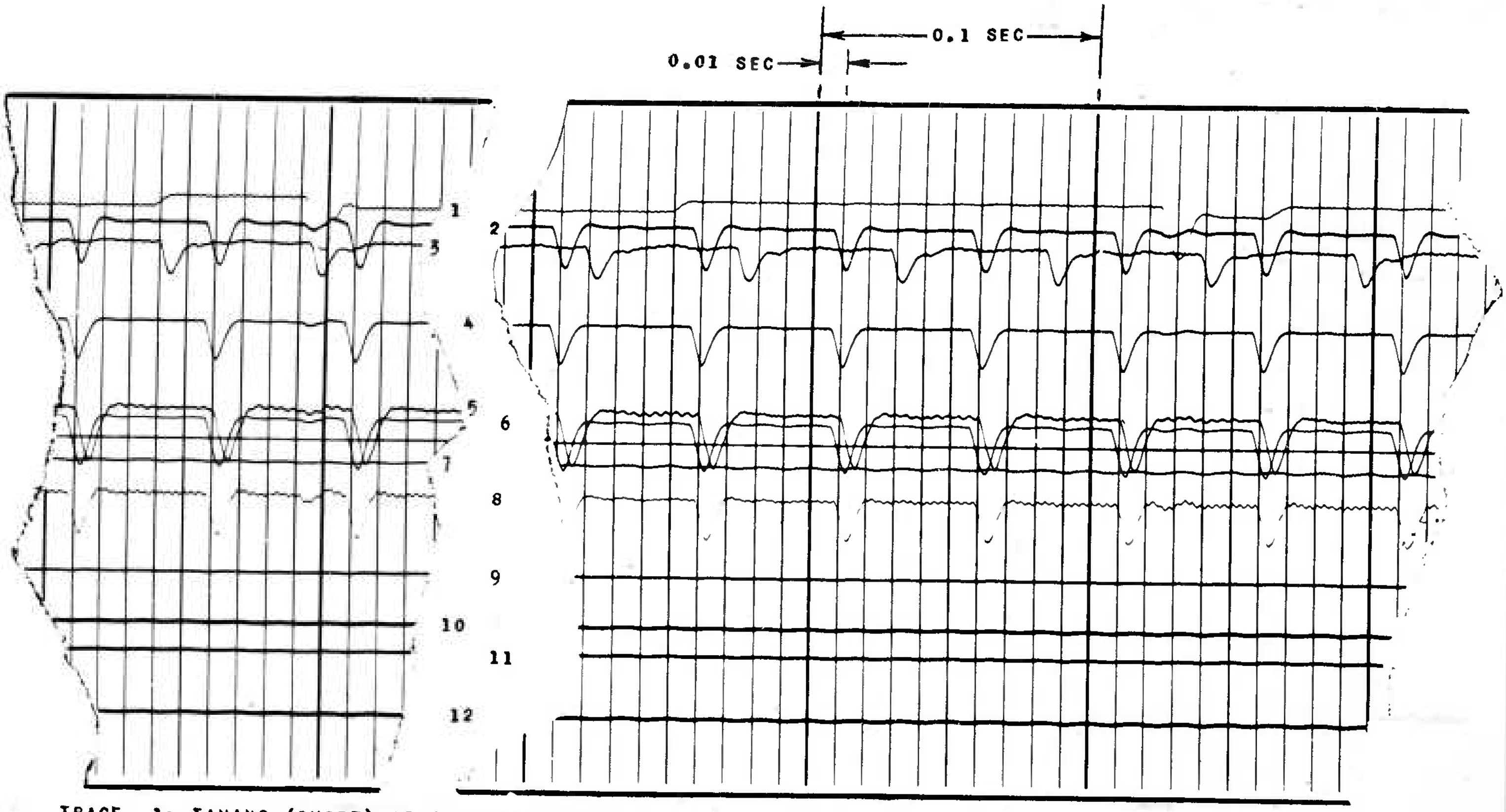
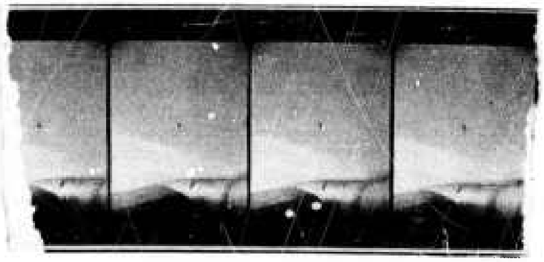
Fighter Cabling

Fig. C_a-2.05. Fighter cabling diagram.

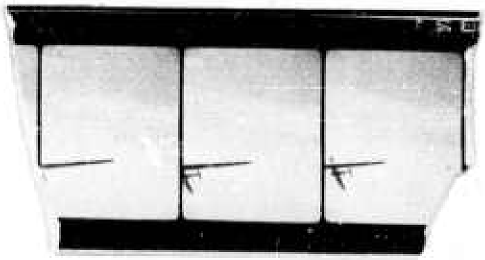


TRACE 1: TIMING (SHORT) OR CATALOG (LONG)
TRACES 2-6, 8: CAMERA SHUTTERS (NO. 3 OUT OF PHASE)
TRACES 7, 9-12: EMPTY

Fig. D_a-1.01(a). Oscillograph record.



TIMING MARKS OCCUR IN PAIRS



CATALOG MARK

Fig. D_a-1.01(b). Film records.

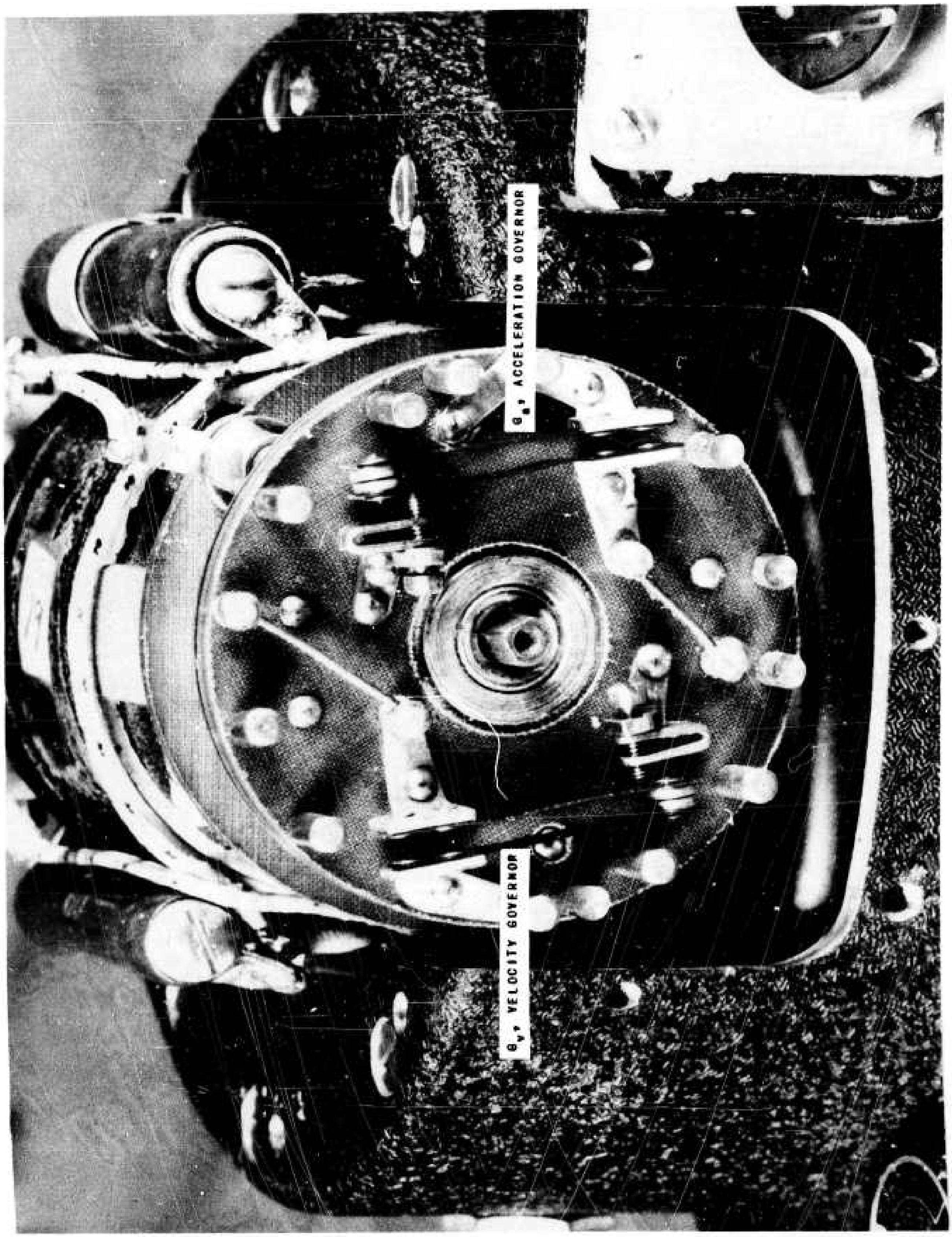


Fig. D_a-1.02. Lee governor on A-4 camera.

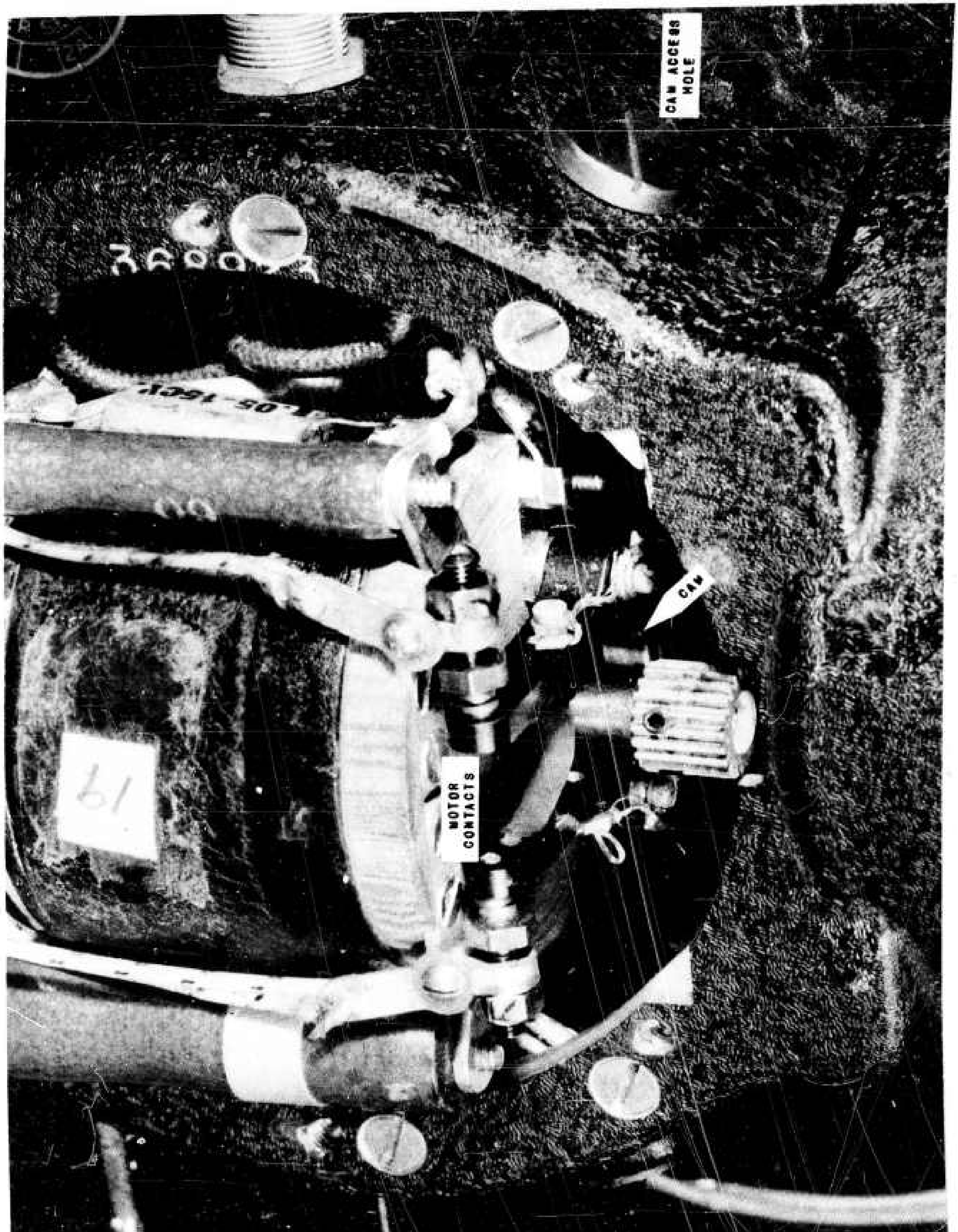


Fig. D_a-1.03. Cam on A-4 camera.

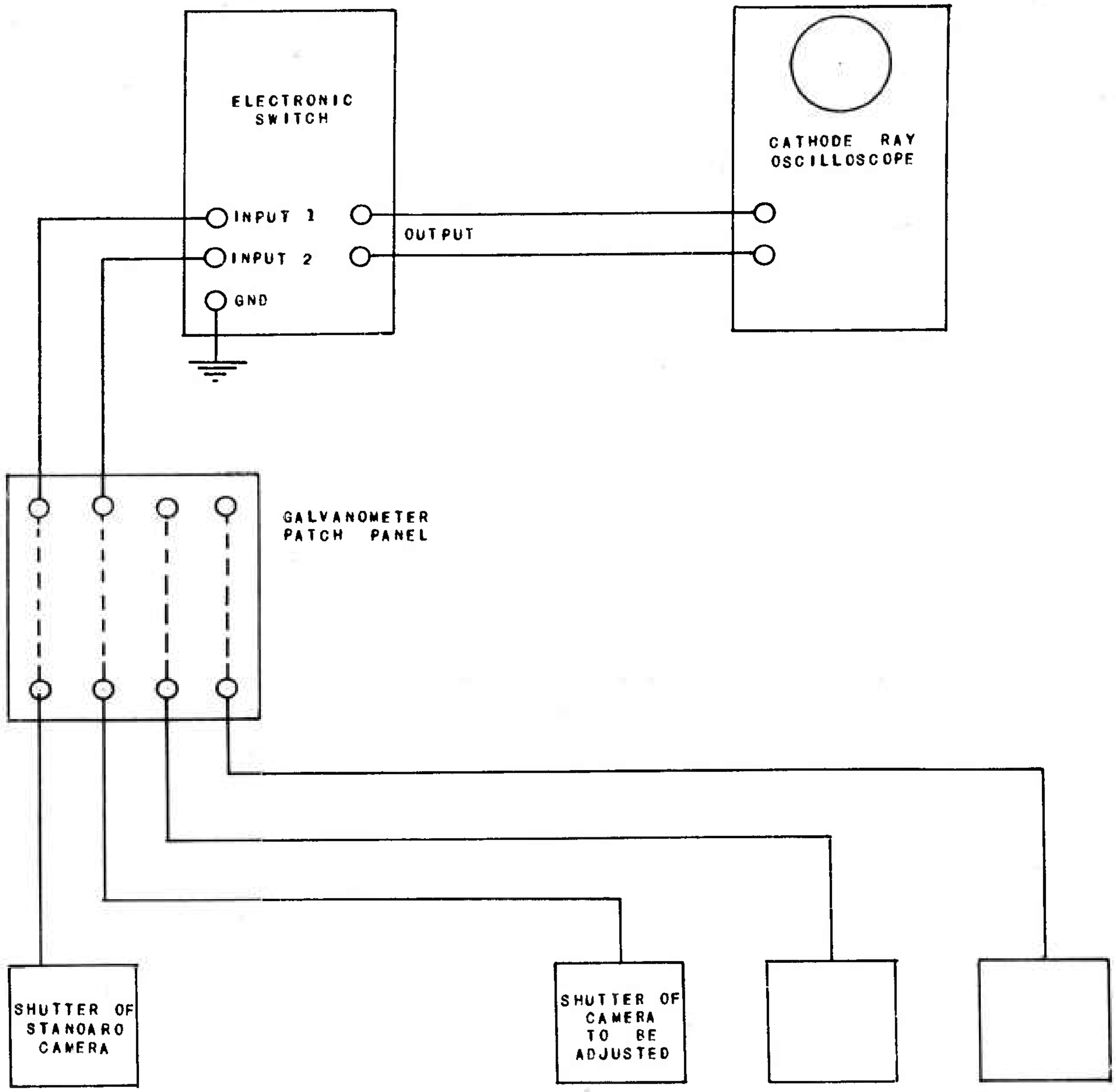


Fig. D_a-1.04. CRO and electronic switch schematic.

ELECTRICAL TECHNICIAN

PREFLIGHT CHECKOFF

F.C.No. ______

Date ________ Flight ________ Time of Check ________

*** BOMBER ***

ON GROUND		FLIGHT	DATE REPAIRS
1. Synch Unit A.C.-D.C. Power Cables Secure Timing OK	______	1. Synch Unit ______	______
2. Gyros Power Floodlights Erection System	______	2. Gyros ______	______
3. Accelerometer Power Floodlights	______	3. Accelerometer ______	______
4. Directional Lights	______	4. Cameras ______	______
5. Changes, installations or repairs made since last flight	______		______
6. Camera operation Timing Lighting	______		______

*** FIGHTER ***

1. Flink-Blink ______
   Sequence
   Timing on cameras
   Wing lights checked and boresighted
2. Manual Check ______
3. Changes, installations or repairs made since last flight ______

NOTES:

Fig. D_a-1.05. Electrical Technician: Preflight Checkoff.

Recorder ________

COORDINATOR - PHOTOGRAPHER

PREFLIGHT CHECKOFF

Date ____________ Flight No. ______________ F.C.No. ______________

COORDINATOR

1. Plane Capt. Checkoff ______________________________
2. Electrical Technician Checkoff ______________________
3. Radar Technician Checkoff __________________________
4. Engineer's Checkoff on Work
   Done Prior to Flight ______________________________

PHOTOGRAPHER

CAMERAS

1. Loading ______________
2. Lens Setting ______________
3. G.S.A.P. Check______________
4. Mounting ______________

A. Forward Crown Gun ______________
B. Aft Crown Gun______________
C. Port Waist Gun ______________
D. Instrument Panel ______________
E. Gyro ______________
F. Razel______________
G. Accelerometer ______________
H. Tail Turret Gun ______________
I. Forward Crown Sight______________
J. Aft Crown Sight ______________
K. Port Waist Sight ______________
L. Offset Gun ______________
M. Tail Turret Sight ______________
N. Radar Scope ______________
O. Radar Calibrator______________
P. ______________
Q. ______________
R. ______________

NOTES:

Fig. D_a-2.01. Coordinator-Photographer: Preflight Checkoff.

Recorder______________________

OBSERVER

LOG

F.C.No. ______

Pilot ______ Date ______ Flight No. ______

Bomber A.T. No. ______ Fighter A.T. No. ______ and ______

Take off time ______ Landing time ______

Assigned Altitude ______ TAS ______ Evasive Action ______

1. BEFORE TAKE-OFF
   Gyros running ______ Range calibration filmed ______
   Borepoint and Boresight checked by film ______

2. BEFORE ATTACKS give sight settings to gunners
   Altitude ______ Wing span ______ IAS ______

3. Attack Record.______Temp. ______ Bomber Lights On ______

Attack No.	Type & Direction	Attacking Plane	Wing Lights On	Actual Alt.	Actual IAS	Gunners Position*	Gunners Name	Remarks
1.								
9.								
10.								
11.								
12.								

4. BEFORE LANDING.______ Gyro Running ______

Recorder ______

* Position of turrets to be listed in this order; N - nose, FC - Forward Crown, AC - Aft Crown, PW - Port Waist, SW - Starboard Waist, T - Tail.

Fig. D_a-2.02. Observer: Log.

MASTER CONTROL OPERATOR

LOG

Date ______________________________

Air: Smooth, rough, bumpy. Flight No.______________ F.C.No. __________

Weather: Clear, cloudy, hazy. Ceiling ________________

1. RYP gyros on ________ off __________ total ______________

2. Attack Record.

Attack No.	Synch Unit Seconds Reading After Attack	RYP Gyros Uncaged Before Attack	Remarks
1.			
2.			
3.			
10.			
11.			
12.			

3. CHANGE-IN-PHASE Reports (if any):

Fig. D_a-2.03. Master Control Operator: Log.

Recorder ____________________

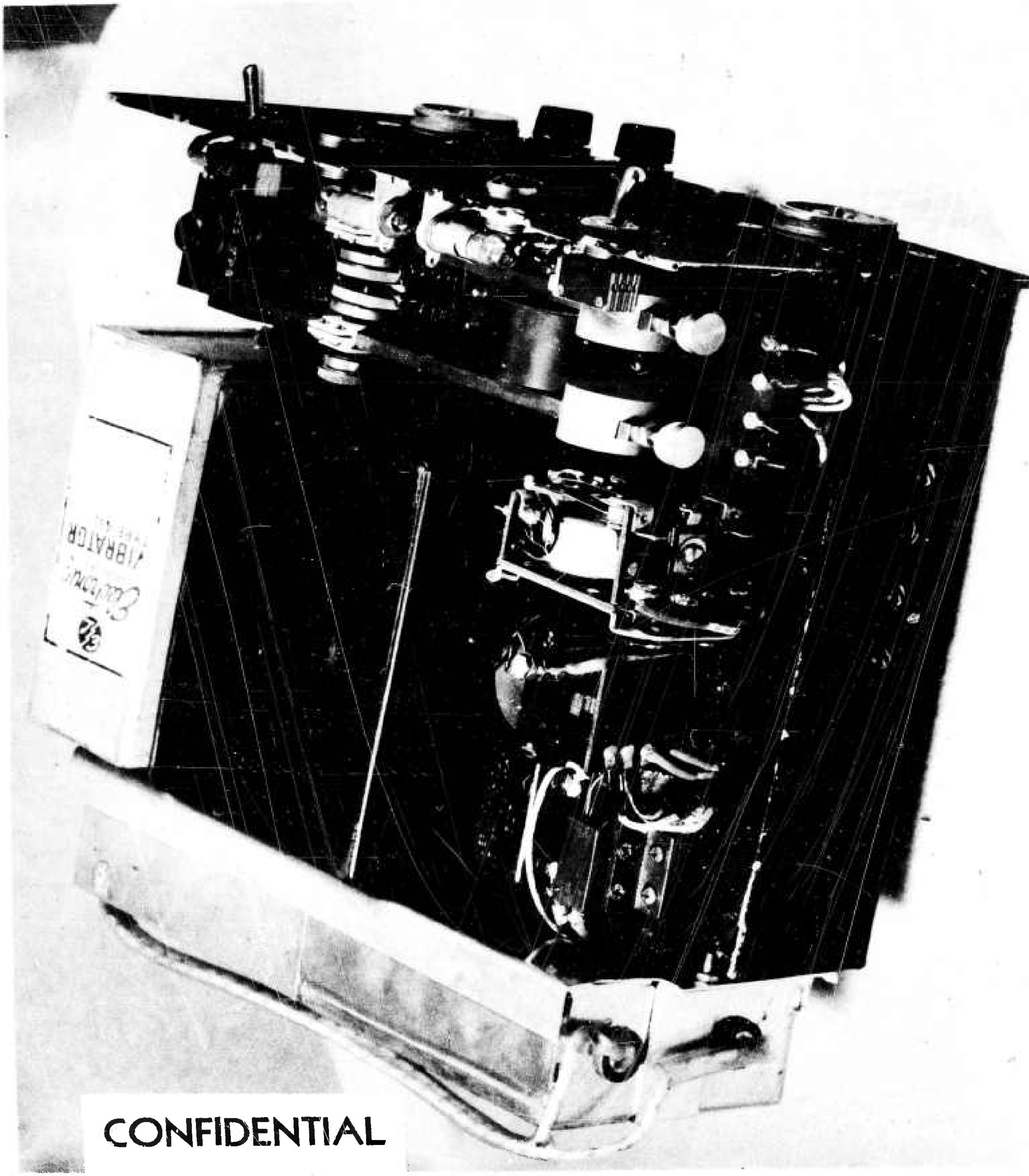


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Fig. D_a-3.01. Tuning fork inverter (TFI).

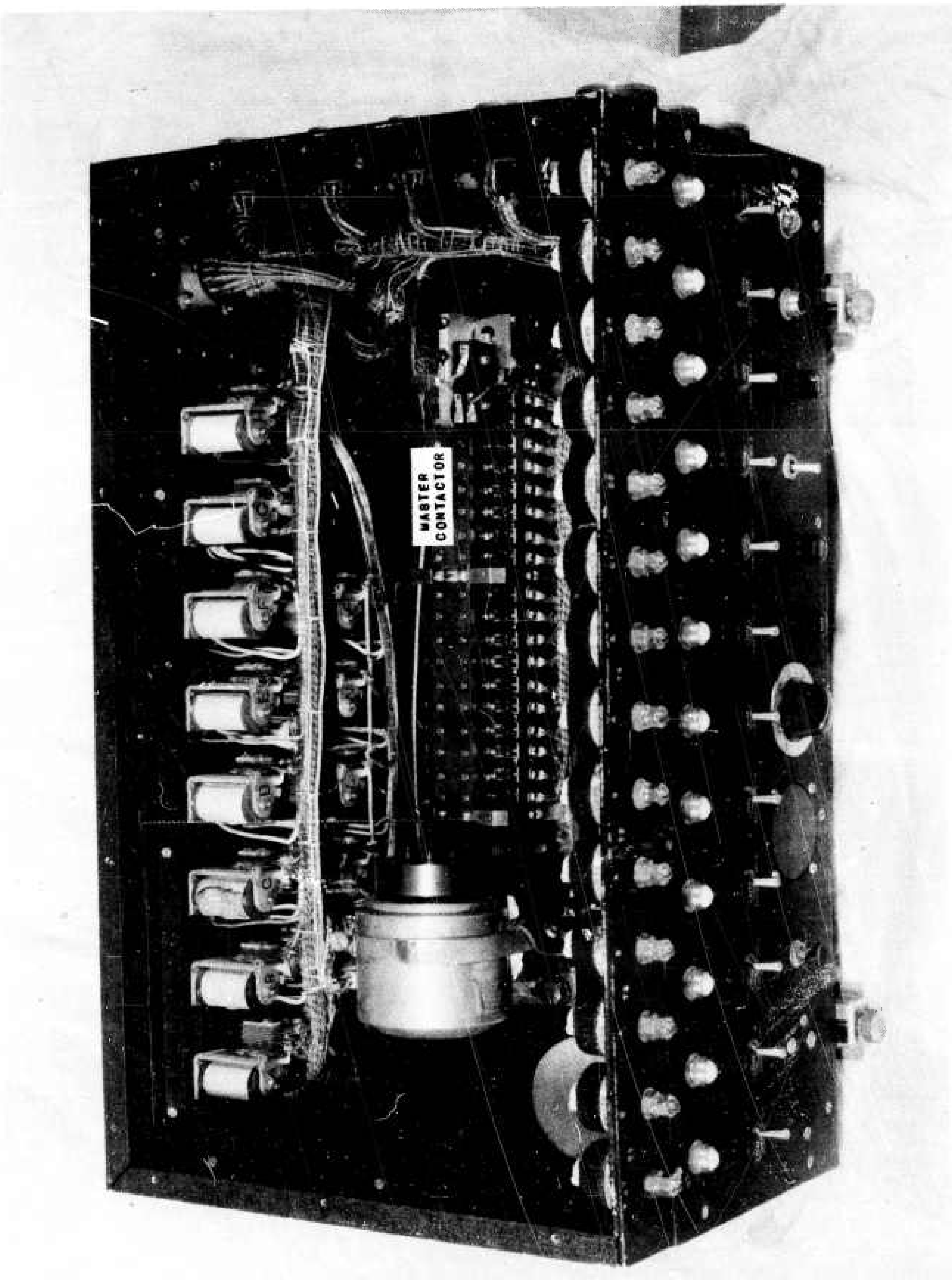

Fig. E_a-1.01. Synch unit Mk III interior, showing contactor.

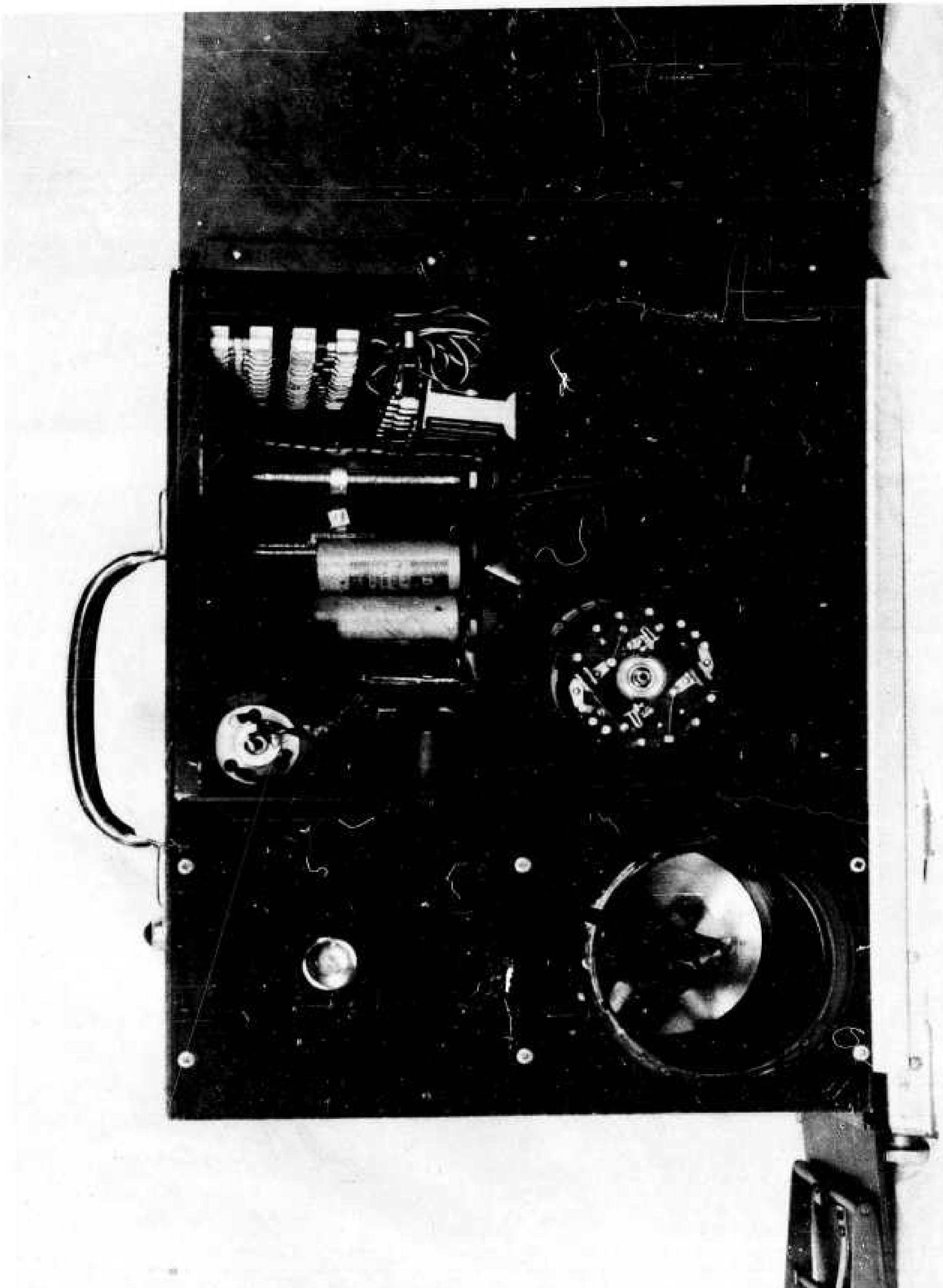

Fig. E_a-1.03. Oscillograph recorder (OR) interior.

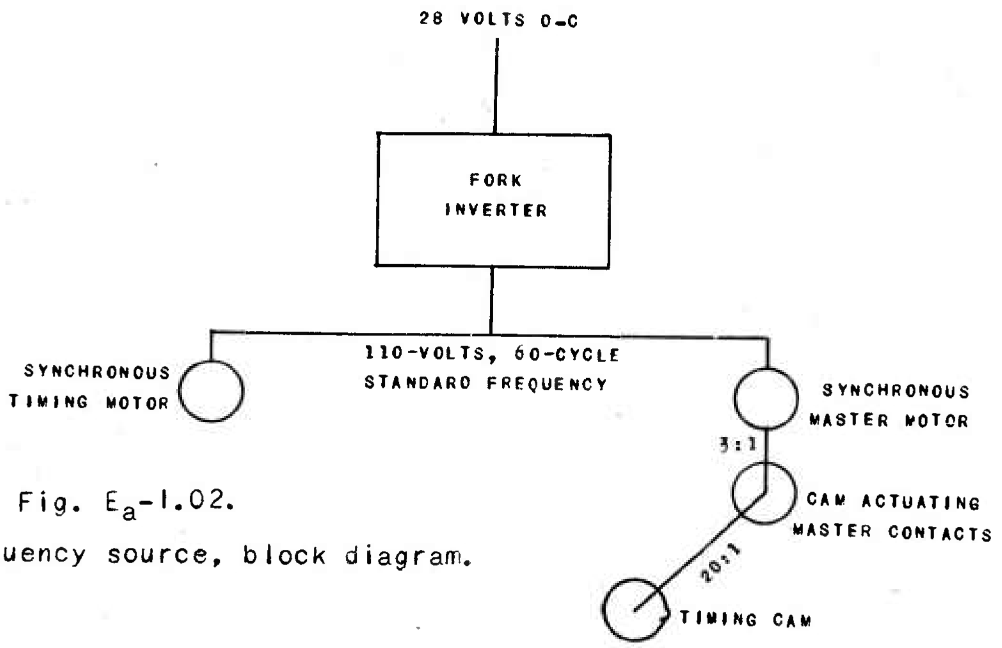

Fig. E_a-1.02.
Standard frequency source, block diagram.

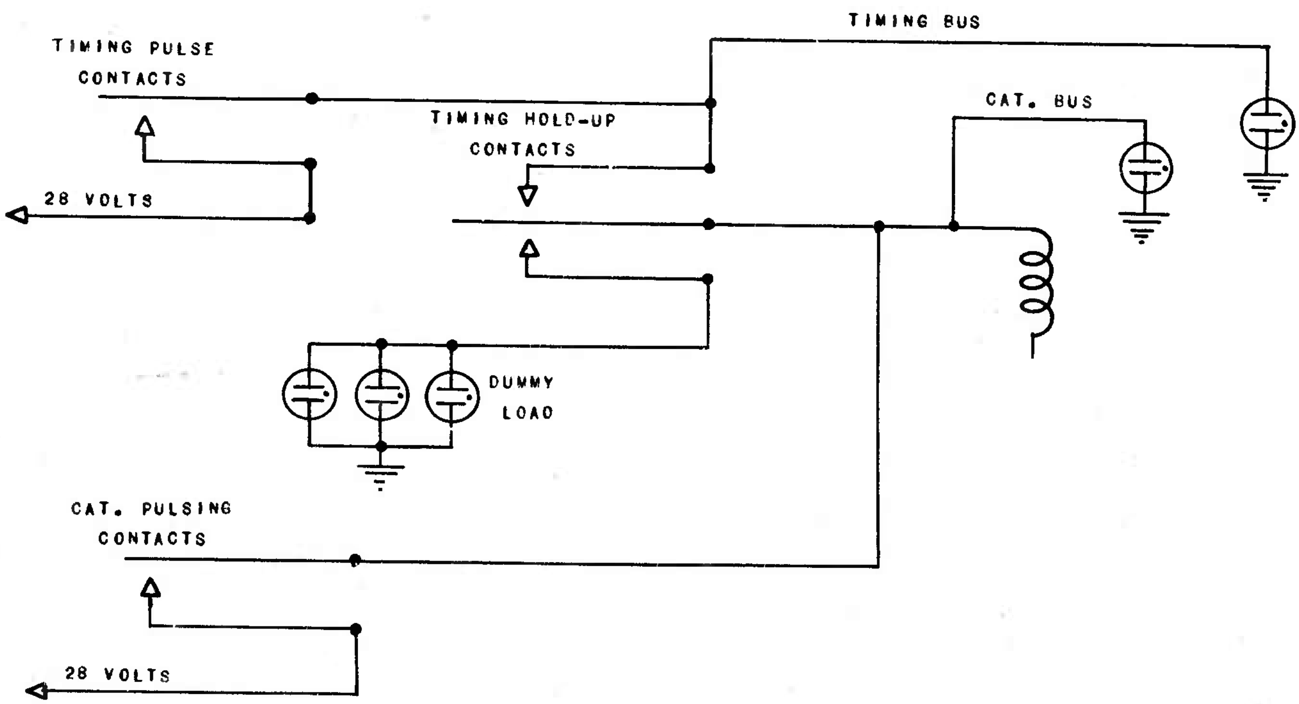

Fig. E_a-1.04. Timing and cataloging circuit.

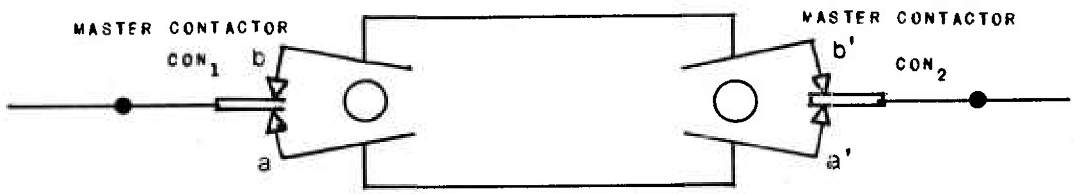

Fig. E_a-1.05. Contact connections.

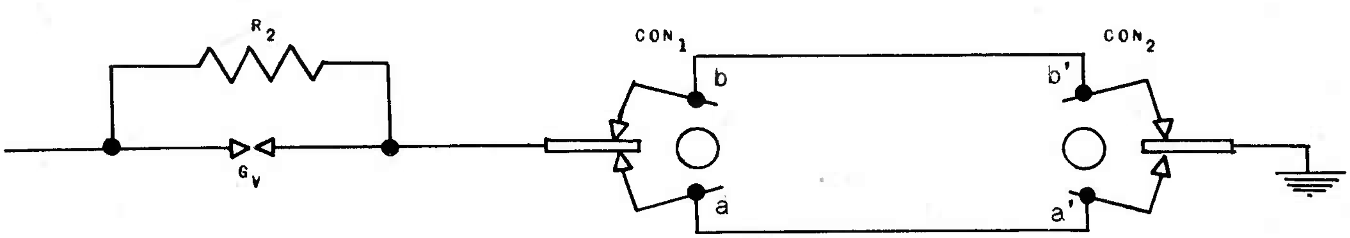

Fig. E_a-1.06. Contactor circuit.

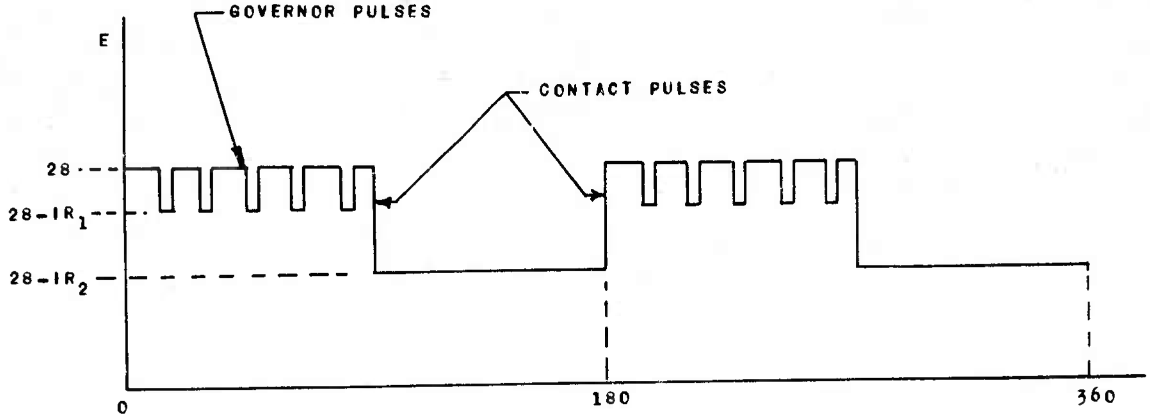

Fig. E_a-1.07. Controlling pulses.

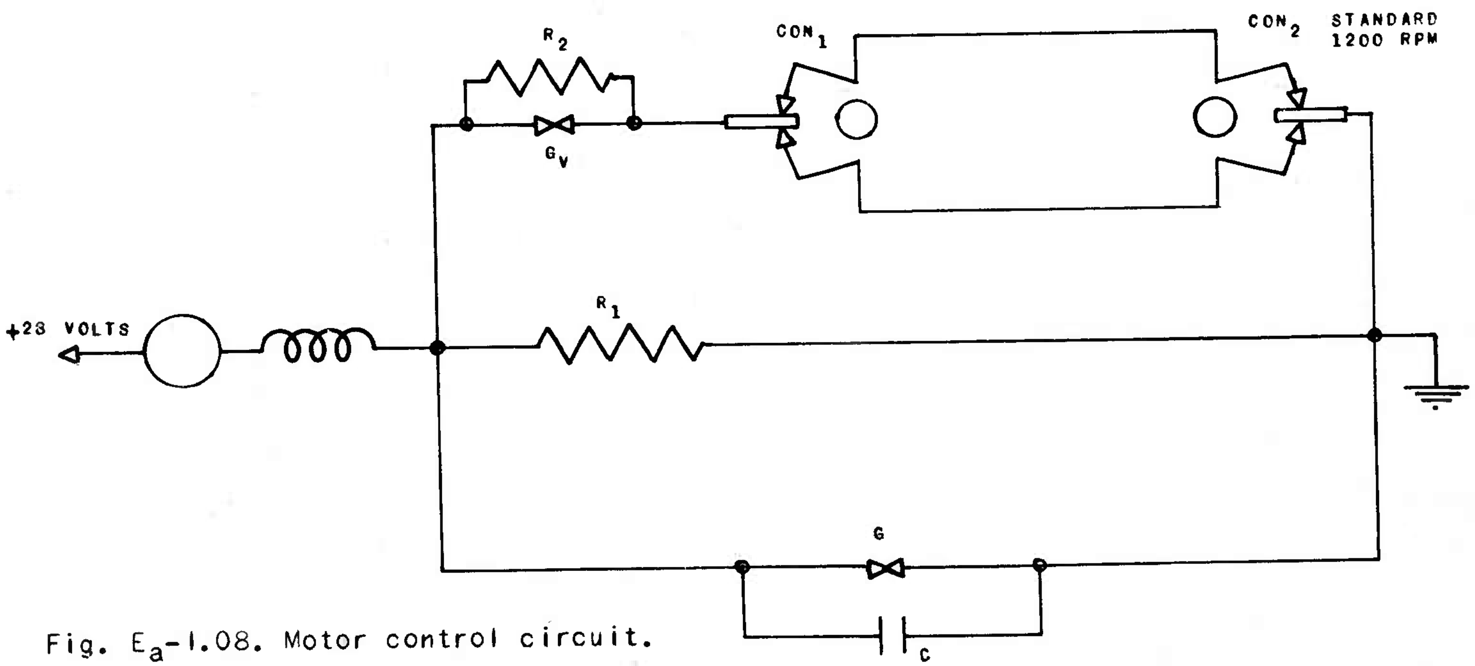

Fig. E_a-1.08. Motor control circuit.

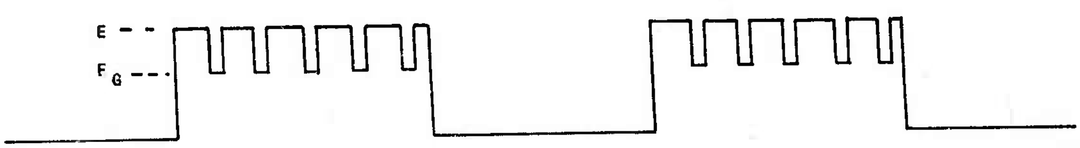

Fig. E_a-1.09. Pulse shape for velocity governor.

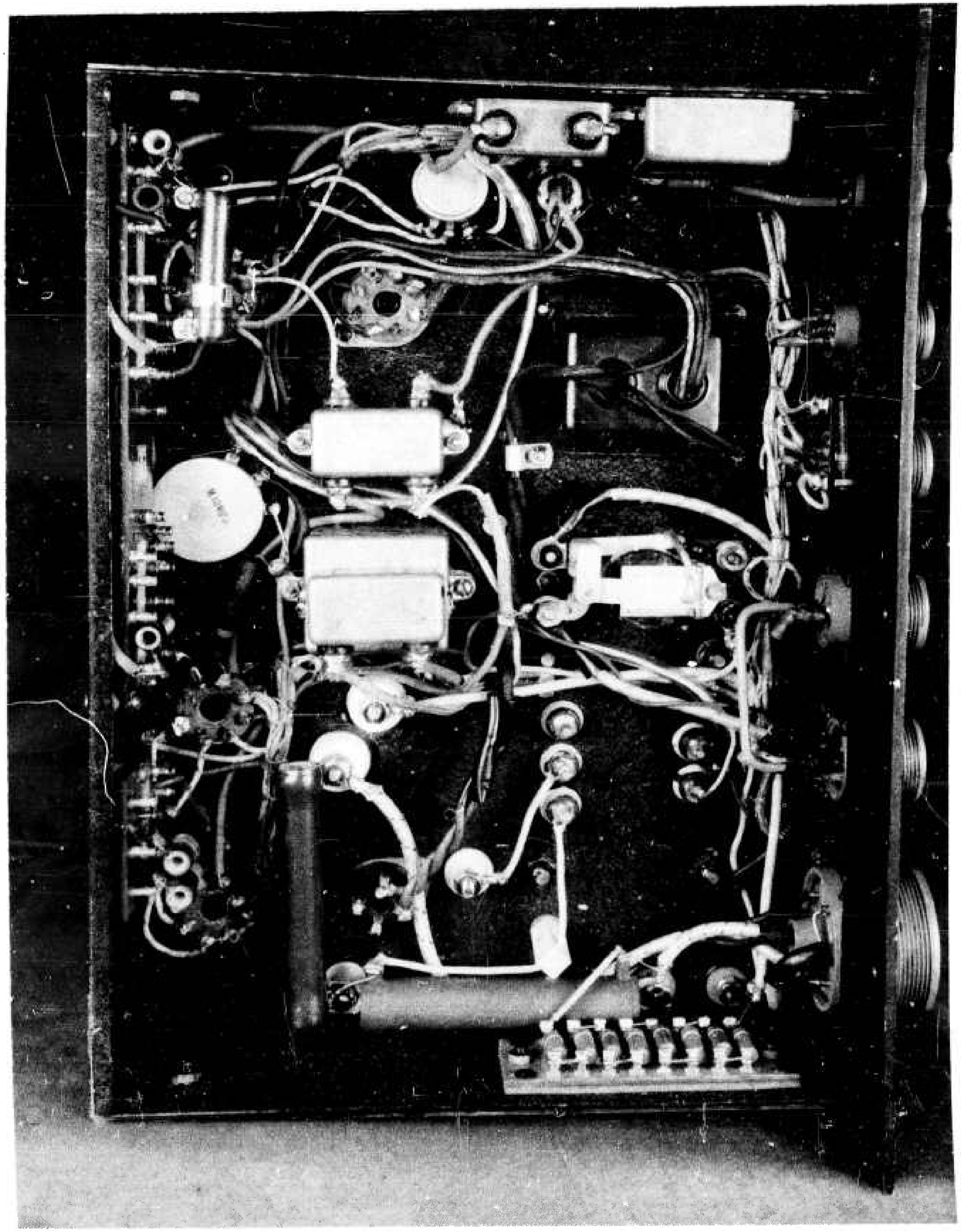

Fig. E_a-2.01. Main flash unit AT-1 (MFU), bottom view.

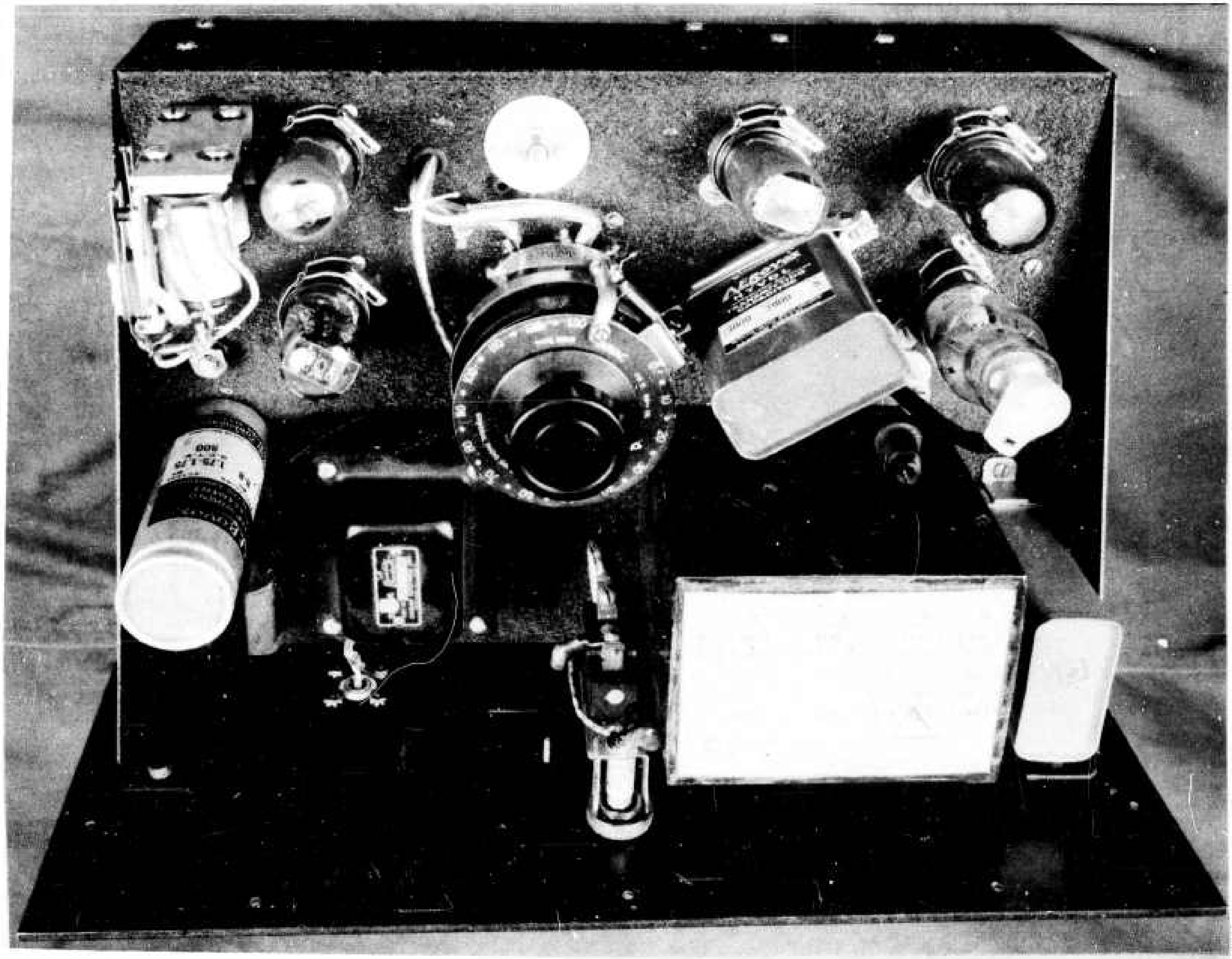

Fig. E_a-2.02. Main flash unit AT-1 (MFU), top view.

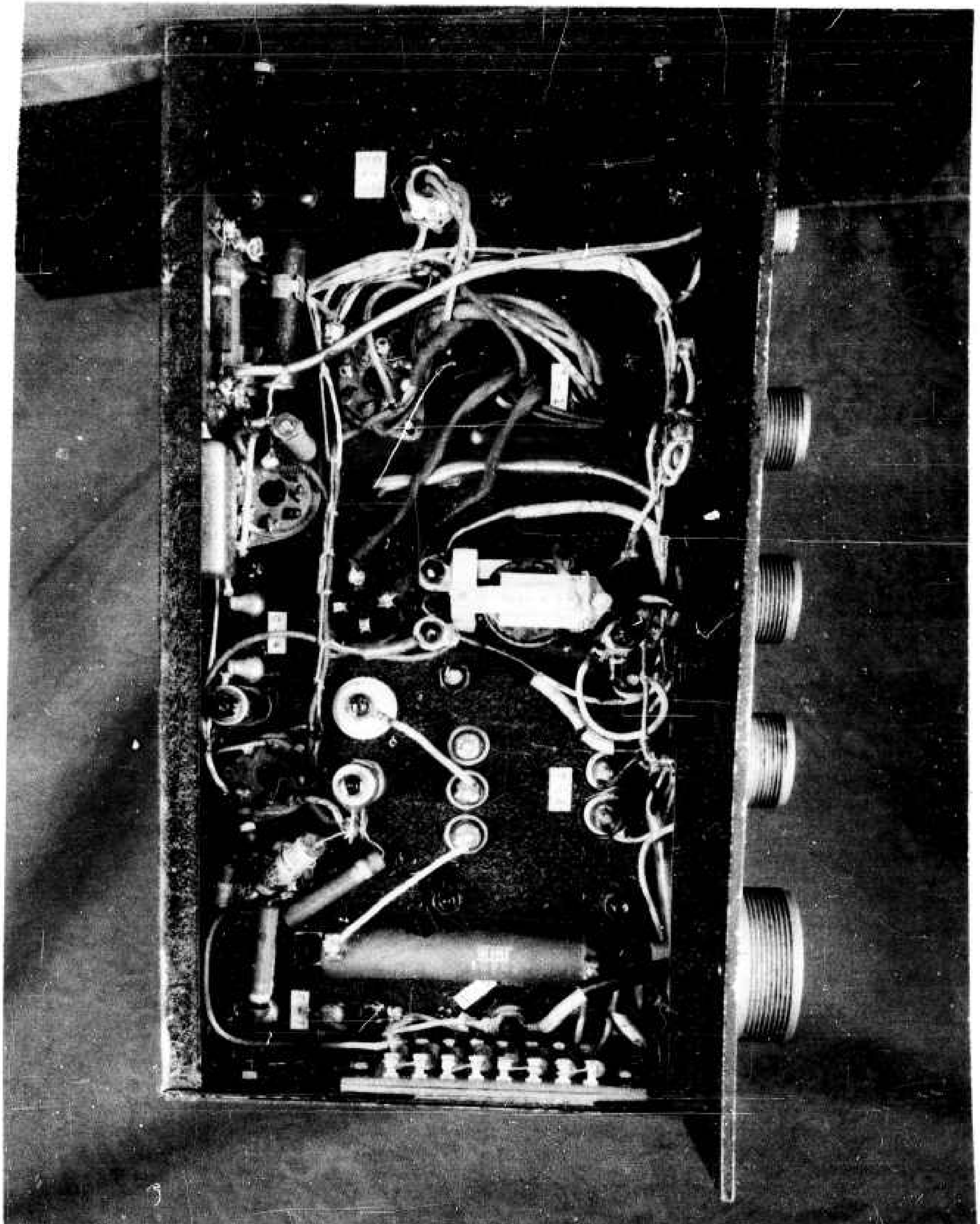

Fig. E_a-3.01. Auxiliary flash unit (AFU), bottom view.

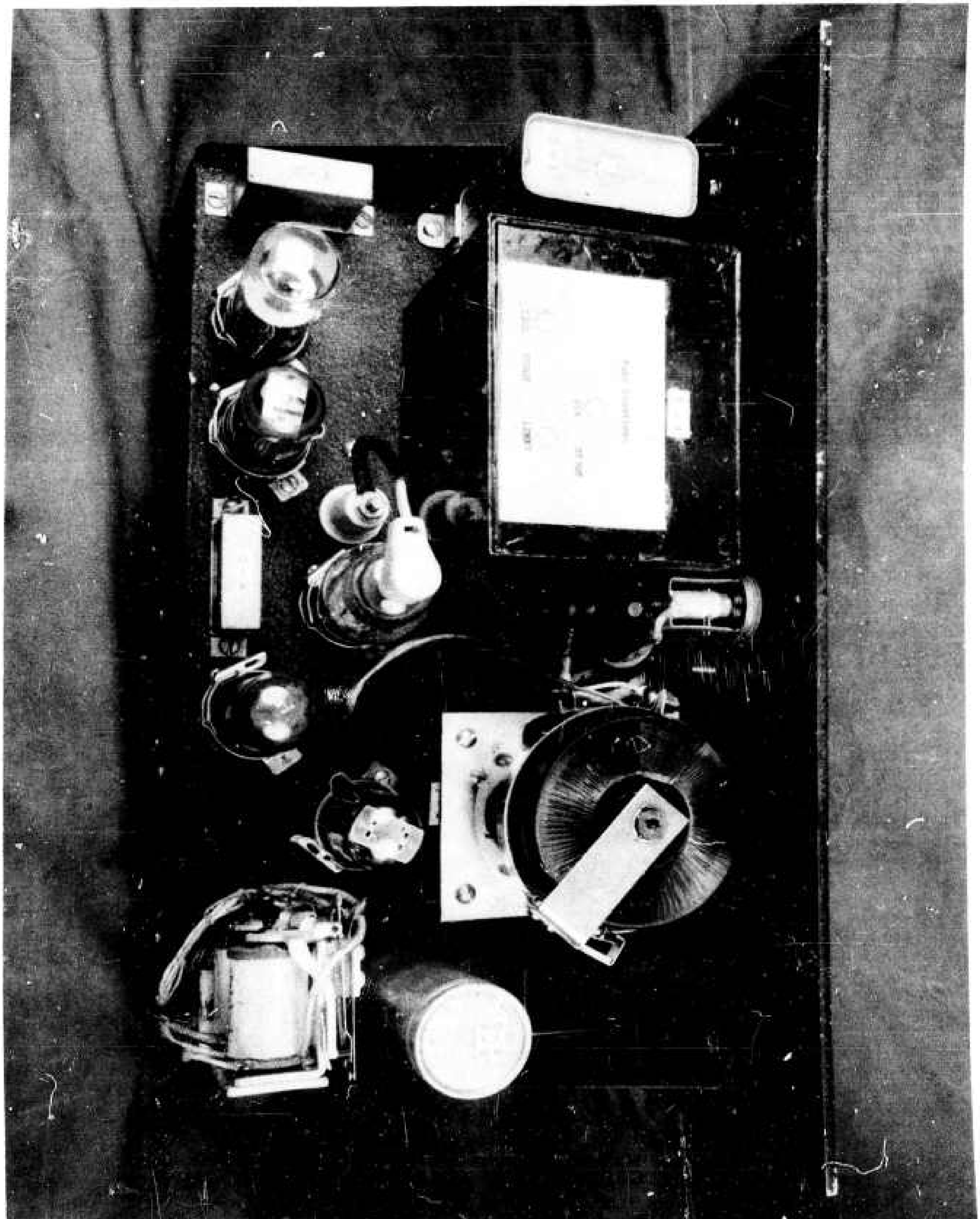

Fig. E_a-3.02. Auxiliary flash unit (AFU), top view.

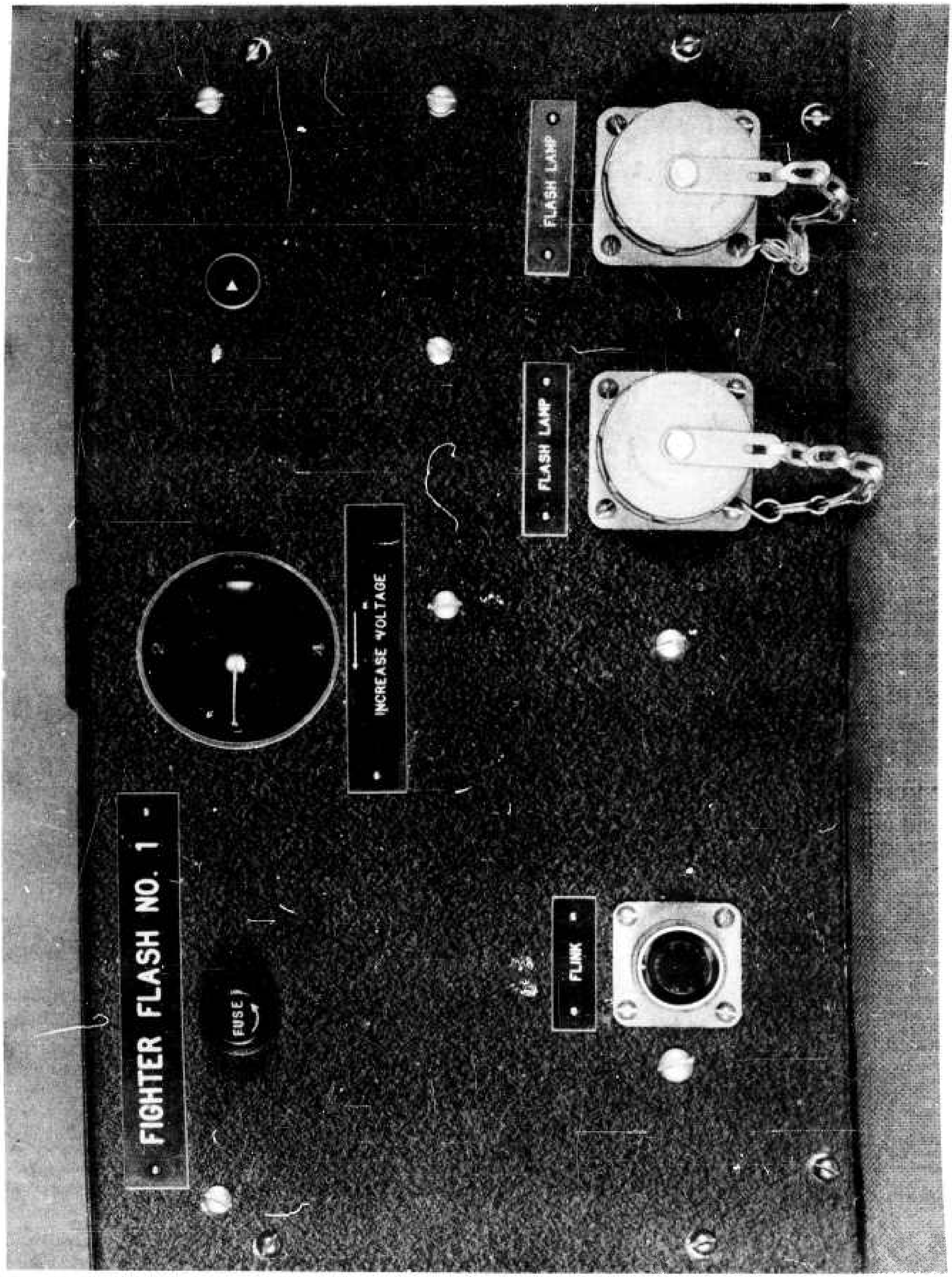

Fig. E_a-4.01. Fighter flash unit No. 1 (FFU).

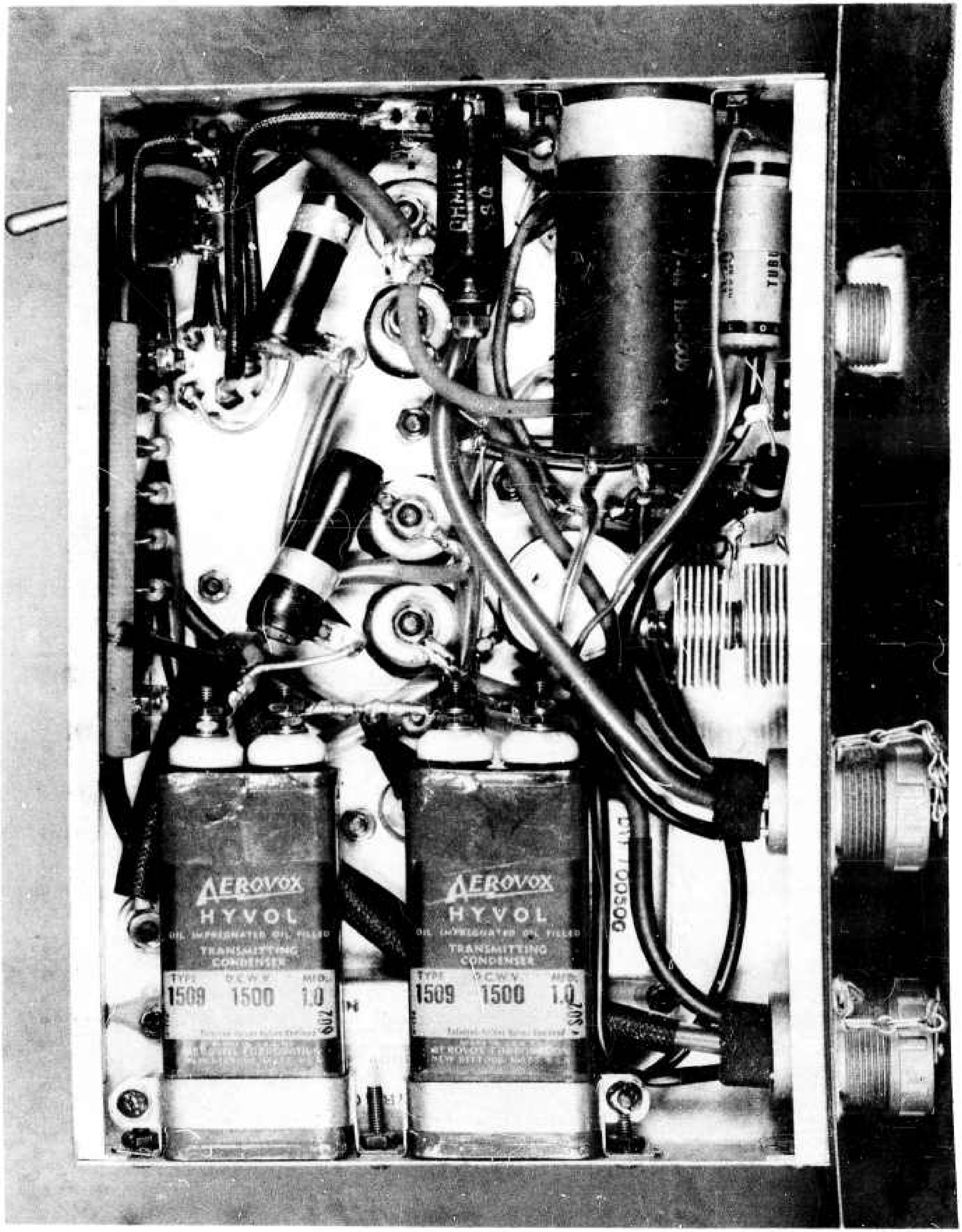

Fig. E_a-4.02. Fighter flash unit No. 1 (FFU), bottom view.

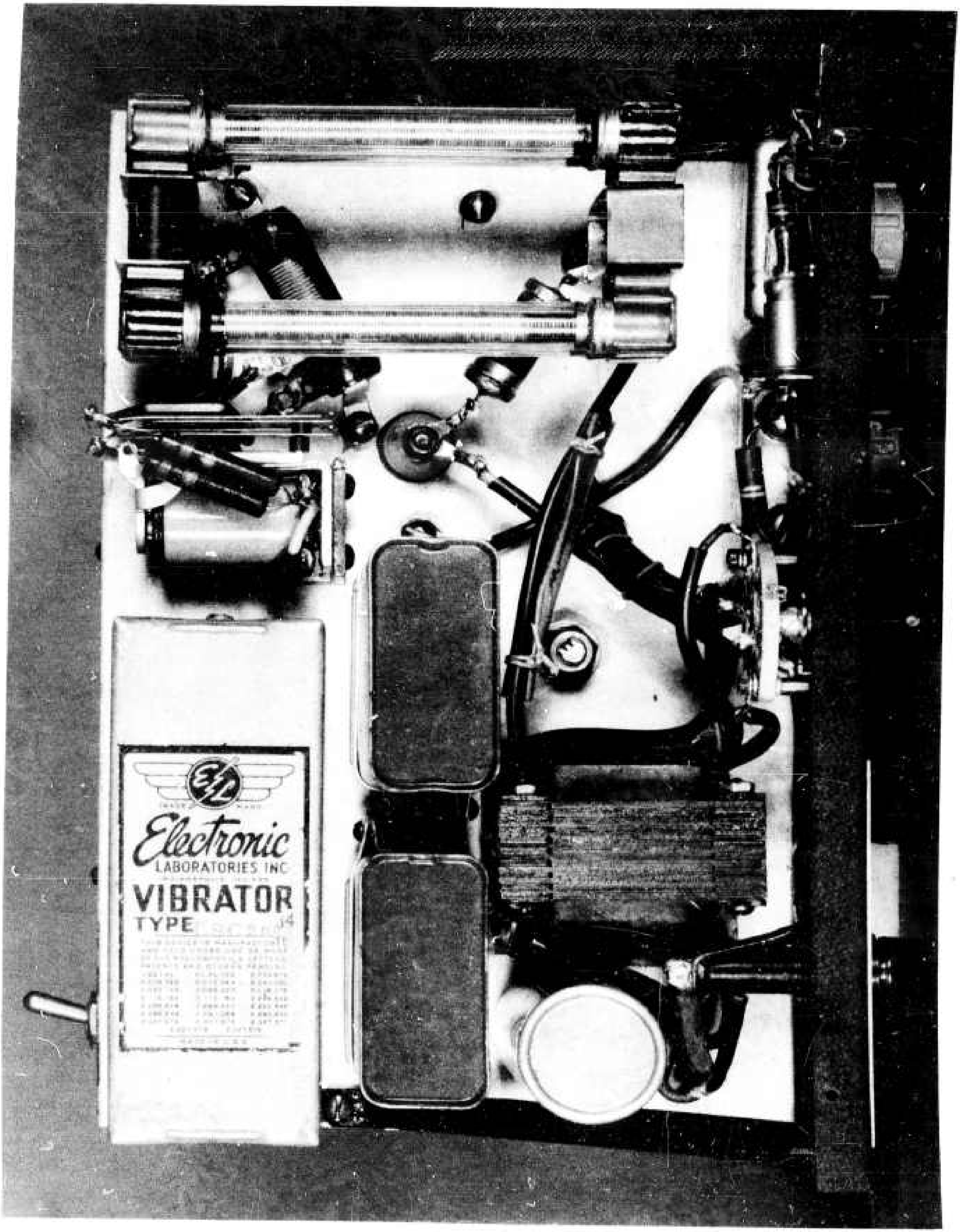

Fig. E_a-4.03. Fighter flash unit No. 1 (FFU), top view.

PARTS LIST

An itemized list of parts, and the source from which they may be obtained, is not included in this First Supplement; the pertinent information is given on the drawings available at Patuxent from the Executive Officer of Armament Test, or at AML, Northwestern University, Evanston, Illinois.

Two components, the Oscillograph Recorder and the Tuning Fork Inverter, were purchased from the Heiland Research Corporation; any replacements for these two units should be obtained directly from the Heiland Research Corporation, 130 East Fifth Avenue, Denver, Colorado.

DRAWINGS LIST

P22E-41-B30B	Circuit Diagram, Synch Unit Mk 3
-B30.1	Circuit Diagram, Master Control Unit Mk 3
- 3-B33	Circuit Diagram, Observer's Control Unit
-41-C71	Timing Choke
-C104	Assembly, Multicontactor 6
-D54B	Timing Switch Drive, Assembly B
-E51	Flink Receiver (ARW-17-Drone Rec. Modif.)
-E51.1	Flink Control System Circuit Diagram
-E51.2	Man.-Auto Box Circuit Diagram
-G44A	Circuit Diagram, Flash Unit
-G45B	Circuit Diagram, Auxiliary Flash Unit
-G45.1	Circuit Diagram, Fighter Flash Unit
-G46	Flash Tube Cable, Auxiliary Flash Unit
-G46A	Flash Tube Cable, Master Flash Unit
-I43A	Circuit Diagram, Oscillograph Recorder
-J43.1A	Fork Inverter Power Supply
-K42	Circuit Diagram, Camera
-M115	Shutter Assembly
-M115.1	Assembly, Contact Point
-P75.4	A-4 Camera Motor
-P75.5	Wiring Diagram A-4 Camera Motor

P22E-41-P86	Assembly, Gear Arrangement
-Q91.1	Contactor, Governor Assembly
-R86.1	Assembly, Governor Motor Brush Holder
-23-U3	Gyro Control Circuit
-U4	Gyro Wiring Diagram
P28E-41-V	Mk 4 Synch Unit, Circuit Diagram
-58-18A	GSAP Lighting Assembly
-19	GSAP Shutter Timer Assembly
-29	GSAP Wiring, Flexible Shaft Drive
-59-1	Flexible Shaft Drive Unit Assembly
-45	Wiring, Flexible Shaft Drive
-61-1	A-4 Light Block Assembly (Focusing Device)
-16	GSAP Focusing Unit Assembly

AML Book of Diagrams titled "Photographic Aerial Assessment Camera Control Wiring Diagram Schematics"

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PHOTOGRAPHIC AERIAL ASSESSMENT

FIRST SUPPLEMENT

TO

EQUIPMENT MANUAL

FOR

AIRBORNE INSTALLATIONS (of 1945, NOa(s) 7632)

NOa(s) 8251

Aerial Measurements Laboratory

Northwestern University

Evanston, Illinois

May 1949

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CONTENTS

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INTRODUCTION

The Equipment Manual for Airborne Installations, Volume 4 of the Photographic Aerial Assessment Series published by Project 22 of Northwestern University, reflected the practice current in 1945. Since that time the assessment procedure and the associated instrumentation have changed under the influence of development, reflection and operating experience. This First "Airborne" Supplement details the advances in airborne equipment as well as changes in technique made over nearly four years, representative of the airplane instrumentation in the spring of 1949.

It is assumed that the reader is familiar with and has access to the Manual mentioned above. Accordingly only as much discussion as seems pertinent to the new material is included, background information being available in the aforementioned Manual. The references made to it will be made as "Airborne Manual 1945".

Unfortunately it was not possible to provide a numerical match between the numbering systems of the Sections, Chapters and Articles of the "Airborne Manual 1945" and this First Supplement. For a more ready distinction between the two, the subscript a is used in this First Supplement.

May 1949
Evanston, Illinois

R. S. Hartenberg

DESCRIPTION OF CAMERA CONTROL SYSTEMS Mk III AND Mk IV

CHAPTER B_a-1

GENERAL PLAN

Art. B_a-1.01. Components of the Mk III and Mk IV Systems. The Mk III camera control system is composed of eight major units, and the Mk IV system of seven units, similar units being interchangeable. Of these units, four of the Mk III and three of the Mk IV contain controls necessary for putting the equipment into operation; the remaining units of the system operate automatically from the control units. The control and automatic units for the Mk III and Mk IV are as follows:

--------- Mk III ---------	--------- Mk IV ---------
Control	**Control**
Synch Unit Mk III (SU), Fig. B_a-1.01	Synch Unit Mk IV (SU), (including Master Control Unit), Fig. B_a-1.06
Master Control Unit (MCU), Fig. B_a-1.02	
Observer's Control Unit (OCU), Fig. B_a-1.03	Observer's Control Unit (OCU), Fig. B_a-1.03
Gyro Control Unit (GCU), Figs. B_a-1.04, 1.05	Gyro Control Unit (GCU), Figs. B_a-1.04, 1.05
Automatic	**Automatic**
BLINK transmitter Mk III, Fig. B_a-1.07	BLINK transmitter Mk III, Fig. B_a-1.07
Accelerometer, Fig. B_a-1.08	Accelerometer, Fig. B_a-1.08
Main Flash Unit (MFU), Figs. B_a-1.09, 1.10	Main Flash Unit (MFU), Figs. B_a-1.09, 1.10
Tuning Fork Inverter (TFI), Fig. B_a-1.11	Tuning Fork Inverter (TFI), Fig. B_a-1.11

The units listed above are those which would normally be used in a complete bomber-fighter assessment. Only the SU, the MCO (for the Mk III), the OCU and the TFI have to do with camera synchronization and control in the bomber; the rest of the instrumentation may or may not be used depending on the data required.

Art. B_a-1.02. The Personnel. Because of the complex nature of the synchronizing and control system, it is necessary that more than one man work on the equipment to prepare (ready) it for flight. Each man involved in this work has certain responsibilities and teamwork is necessary to insure successful flights yielding significant data. The following positions have to be filled for successful operation:

1. Electrical Technician (ET).
2. Coordinator-Photographer.
3. Master Control Operator (MCO).
4. Observer (Obs).
5. Pilot.

Practice at Patuxent has shown that some of the duties may be combined, e.g., the Electrical Technician can function as Master Control Operator, the Coordinator may also be the Photographer, and the Fire Control Project Officer the Observer.

Art. B_a-1.03. Outline of the Standard Operating Procedure. A successful standard operating procedure is given below in outline; details are discussed in Section D_a, Duties of Personnel:

1. The Electrical Technician makes a preflight check of the synch equipment and certifies to its readiness by signing the Preflight Checkoff, Fig. D_a-1.05.

2. The Coordinator-Photographer makes a photographic pre-flight check, loads the cameras, and signs the Coordinator-Photographer Checkoff, Fig. D_a-2.01.

3. The Coordinator-Photographer as part of his job sees to it that all men concerned are ready for the flight and notifies the Pilot when all is ready.

   Note: This step in the procedure has been found to be of major importance in preventing human errors in preparing for the flight.

4. The Master Control Operator readys the synch system and erects the gyros after takeoff.

5. Step 4 indicates to the Observer (through Observer's Control Unit) that the equipment is ready; the Obs then assumes control from his position where he can start and stop cameras while watching the opposing airplane make its attack.

6. After the flight is completed, the Coordinator-Photographer unloads the film and has it processed.

7. The Coordinator-Photographer gathers all flight logs and the processed film and turns it over to the Assessment House for analysis.

CHAPTER B_a-2

DESCRIPTIONS OF THE COMPONENTS

Art. B_a-2.01. Function of Synch Units. The synch unit, Figs. B_a-1.01 or B_a-1.06, has two primary functions. First, it provides camera synchronization, i.e., a means of running cameras (16- and 35-mm) at the same frame speed; and, second, it provides an electrical interlocking guard circuit to prevent accidental stopping or starting of the cameras. A definite control sequence is necessary, inasmuch as only 75 seconds of film are available for any given flight.

The following description of the SU applies to the Mk III as installed in the PB4Y-2 AT 24 test aircraft. This is a permanent installation and particular care has been taken to make the installation sound as well as easy to handle. This layout forms the pattern for any future installations.

The Mk IV system is functionally the same as the Mk III, differing in mechanical and electrical details. Appendix A_a details the difference and the electrical sequence.

Art. B_a-2.02. Operation of the Synch Unit Mk III. The complete camera synch and control system is mounted in a rack on the starboard side of the flight deck, Fig. B_a-2.01. The SU is mounted on the second shelf of this rack; the electrical cables connect to the right side and back by means of Amphenol connectors.

The front panel of the SU, shown in Fig. B_a-1.01, has a switch for each TURRET outlet and CAMERA outlet, a 28 VOLTS switch and a BLINK on switch. Closing the 28 VOLTS switch supplies power to the SU, MCU, TFI, OR and MFU. The BLINK switch supplies filament power to the transmitter, readying it for operation. Each of the CAMERA or TURRET switches completes the circuit to the camera or turret indicated on the switch. It is apparent that if all the above units are connected permanently to the SU they can easily be controlled through the switches on the SU or the patch panels. Both the Mk III and the Mk IV SU's have the camera control switches built into the SU.

The front panel of the SU also contains 28 VOLTS ON indicating light, an a-c power-on indicating light labeled AC FUSE, and 17 phasing potentiometers. The function of these potentiometers is described in Chapter D_a-1. In addition to these controls and indicators, a safety device in the form of a FUSE TEST circuit is also included on the front panel: should any of the camera fuses blow during test or flight, then an indicator light directly above the blown fuse glows. This circuit is fully described in Chapter E_a-1.

Three meters are wired into the SU circuit but mounted just outside the unit itself, as shown in Fig. B_a-2.01; they give the d-c input voltage and current to the TFI, and the a-c output voltage of the TFI to the SU.

Art. B_a-2.03. The Master Control Unit (MCU). The MCU, Fig. B_a-1.02, is cabled into the synchronizing system by means of connectors mounted on the right-hand panel. The front panel of the MCU has the following operating controls:

1. Dial. This is used to indicate the number of the assessment attack being made, e.g., before the third attack of the fighter plane the MCO would dial 3, and the dial would stay at 3.

2. DIAL RESET Button: This is immediately below the dial; pushing it releases the information put into the dial should it be desirable to do so.

3. READY Button: This energizes all the circuits to that stage where the cameras are ready to photograph; a green READY light glows on both the MCU and the OCU.

4. START Button: This puts all cameras, the FU and the oscillograph into operation. This START button is used only for test purposes, for the MCO is never in a position to see the impending attack from his station at the MCU. The START button also gives a visual indication by means of a CAMERAS ON light on both the MCU and the OCU.

5. STOP Button: This is used by the MCO to stop the synch system in case of emergency, as trouble of any sort coming to the attention of the MCO.

The MCU also contains indicating lights for TIMING, CATALOG, radar ON TARGET, and turret FIRING indicators for all four turret plugs of the SU. It also contains a GOOD RUNS counter and a SECONDS counter to assist the MCO in keeping track of the film supply.

Art. B_a-2.04. The Observer's Control Unit (OCU). The Obs controls the camera action through the three push-button switches on the OCU, Fig. B_a-1.03. Since the Obs is so stationed that he can see the action at all times, he must relay all information by interphone to the others concerned with the system operation. The MCO will bring the system to READY by the time the fighter plane is in position to start the attack, at which point the Obs assumes control. As the fighter starts to come in, the Obs calls to the MCO for the READY light. When this comes on, the system is ready to operate, and the cameras are be started by pressing the START button. The CAMERAS ON indicator glows while the cameras are running. The Obs starts the cameras when in his opinion the fighter is within the range set by the particular problem. If for any reason the attack does not proceed as it should, the cameras can be stopped immediately by pressing the STOP button. A properly executed attack is terminated by pressing the CATALOG button. This will stop the cameras and automatically insert the previously dialed attack number on the film.

Art. B_a-2.05. The Gyro Control Unit (GCU). The actual operation of this unit (Fig. B_a-1.04) is fairly simple, although the circuits, erecting mechanism, and particularly the theory on defining the sequence of operations are complex. It is therefore necessary that the MCO become thoroughly familiar with the gyro material of Chapter E-6 of the "Airborne Manual 1945". Before the gyros are used for flight recording, they should be run for at least one hour to bring them to a stable operating condition. The preflight check period and the time between take-off and the start of an attack may be utilized for warm-up. The unit is powered by the plane's battery system. The toggle-switch shown in Fig. B_a-1.04 energizes the gyros, indicated by the POWER lamp.

The six-position rotary switch controls the erection system and should be in No. 1 position during warm-up of the gyros. Several minutes before the first attack, the switch should be advanced to the second position, remaining there until one of the pairs of indicator lamps marked HOR. STAB. ERECT go out. The switch is then advanced to the No. 3 position and remains there until the remaining pair of indicator lamps go out. The switch is kept at the next or No. 4 position until the MCO learns from the observer that the fighter plane is in attacking position and is ready to begin the attack. Correct gyro operation at this point is indicated by the flickering of the SOLENOID ERECT indicators. (If these indicators glow steadily, the first four switch operations should be repeated). The MCO now advances the switch to the No. 5 position for one-half second and then to No. 6 position for the remainder of the attack.

This procedure is repeated for each attack. However, for attacks other than the first, the first four switch operations may immediately follow the completion of the previous attack. In other words, the gyros must be operating in the No. 4 position when the attack is about to start.

The gyro installation in PB4Y-2, AT 24 is shown in Fig. B_a-1.05. The switchbox in the lower right corner is wired in parallel with the GCU, and permits the Technician to run through the erection procedure without recourse to the GCU.

Art. B_a-2.06. The Cameras. The two types of cameras shown in Figs. B_a-2.02 and B_a-2.03 are used with the present synch system. One is a motorized A4 35-mm camera, and the other is a 16-mm GSAP camera rebuilt to be driven by a flexible shaft from the gearbox and motor shown in Fig. B_a-2.04. Both cameras are synchronized and have in common the following features:

1. Timing light - a neon light built into the camera to put on identifying mark (timing mark) on the edge of the film once a second.
2. Catalog light - a neon light built into the camera to put an identifying mark (cataloging mark) on the film at the end of each attack corresponding to the number set in on the dial.
3. A shutter contact which puts an identifying pulse on the oscillograph tape each time the shutter reaches maximum opening.

In addition, the 35-mm camera has a thread-switch to aid in loading the film; the camera may be run from this switch without running the entire system.

Further details are given in Section E_a.

Art. B_a-2.07. The BLINK-FLINK. The BLINK transmitter is an FM radio transmitter in the bomber operating on about 36 megacycles; it transmits tone signals corresponding to the operations (READY, START, TIMING, CATALOG) of the SU. If these signals are received in another aircraft, e.g., a fighter, by a FLINK receiver and converted into control voltages through the FLINK Conversion Unit (FCU), the cameras in the second airplane can be operated and controlled from the bomber. This combination is known as the BLINK-FLINK; the modifications of the basic drone transmitter and receiver are described in Appendix B_a. The transmitter is connected to the SU from which it gets its power and control by a single cable terminating at the transmitter with a Detrola B-52004 plug. If the transmitter switch (Fig. B_a-1.07) is in the ON-position, the transmitter operation is automatic; if the BLINK is not to be used, this switch is turned to OFF.

Art. B_a-2.08. The Main Flash Unit (MFU). The flash unit is a high speed photoflash used to illuminate dials and instruments for photographing; a picture is taken during flash period. Since this is electrically triggered, it allows synchronization with other electrically controlled functions. The operating pulses for this unit are received from the SU, but the power, 28 volts direct current and 110 volts at 400 cycles, is taken from sources external to the SU. This unit, controlled as it is from the SU, is completely automatic, and has no external controls.

For instrument cameras using flash illumination a special camera cabling circuit is needed. This special circuit is detailed in Chapter E_a-2.

> Note: This unit carries the very dangerous potential of 2800 volts. It should never be handled by anyone but the Electrical Technician qualified to do so.

Art. B_a-2.09. The Accelerometer. The accelerometer is non-electrical and requires no wiring into the SU system. Its information is shown on three closely grouped dials and photographed by a 35-mm camera; Fig. B_a-1.08 shows the general plan. The unit is mounted in the forward bomb-bay on the starboard side; a camera junction box is on the bomb-bay bulkhead. For details see Chap. D-4 of "Airborne Manual 1945".

Art. B_a-2.10. The Tuning Fork Inverter (TFI). This unit, shown in Fig. B_a-1.09, is a standard frequency source supplying 110 volts at 60 cycles to operate the master synchronous motor in the SU and the timing motor in the OR. The unit is connected to the SU by a single cable; operation is automatic.

INSTALLATIONS, MECHANICAL AND ELECTRICAL

CHAPTER C_a-1

MECHANICAL INSTALLATIONS IN BOMBER AND FIGHTER

Art. C_a-1.01. Bomber, PB4Y-2, AT 24. All fixed or permanent units are when possible grouped together to facilitate operation, supervision and maintenance and provide short connecting cables. These units - the synch unit, master control unit, tuning fork inverter, BLINK transmitter, gyro control unit, oscillograph recorder and two patch panels - are mounted in a rack, built for the purpose on the starboard side of the flight deck, as shown in Figs. B_a-2.01 and C_a-1.14.

All units are mounted on Collins shock mounts. The clearance dimensions shown in Figs. C_a-1.01 to C_a-1.14 include the shock mounts and space required for cable connections.

As shown in Fig. B_a-2.01, the units requiring no manipulation while in flight are mounted on the lower shelves. Those units requiring access, i.e., SU, MCU, GCU and OR, are mounted at a convenient height for the use of the MCO during flight. The patch panels (which are connected before flight) are set on top and are recessed; the patch cables are available but out of the way.

The main flash unit shown in Fig. B_a-1.10, is not mounted in the main rack; it is placed forward of the rack near the forward crown-turret, giving the shortest possible leads from the flash unit to the lights.

The gyro unit is mounted aft of the equipment rack in the place formerly occupied by the navigator's table; the accelerometer is mounted to starboard in the forward bomb-bay. Both of these units should be placed as close as possible to the center of gravity of the aircraft; Figs. B_a-1.05 and B_a-1.08 show them.

Art. C_a-1.02. Purpose of Surveying-In. The matter of determining significant airplane dimensions, establishing reference axes and aligning cameras and instruments thereto, has been discussed in Arts. D-2.09 to D-2.16 of the "Airborne Manual 1945" in terms of the instrumentation used in the fall of 1944.

The purpose of the following is to describe a surveying procedure for a PB4Y-2 not only adapted to the latest assessment procedure, but also to detail other methods. For the sake of completeness, the basic philosophy is first reviewed in the following.

Camera and certain instrument-orientations must be known with respect to the airplane in order to establish the basic geometric relations. Accordingly, an origin and a set of rectangular axes must be chosen. The origin chosen is the center of the roller-path of the forward crown-turret, designated master turret, with the X-axis forward, the Y-axis to starboard and the Z-axis up. With the airplane jacked to make the XY-plane horizontal, it is then possible to locate parallel planes anywhere else in the airplane by means of a precision level, to locate axes parallel to the X- and Y-axes by means of a surveyor's transit, and to locate axes parallel to the Z-axis by means of a plumb-line or transit. It is to such local axes, respectively parallel to those of the master turret, that certain cameras, borelines and instruments are aligned to permit reconstructing the geometry of an aerial encounter on the ground, i.e., in the Assessment House. (The features of the ground reconstruction are explained in the Equipment Manual for Ground Installations).

Art. C_a-1.03. Bomber Location for Surveying. The method of surveying to be described in this Supplement makes fewer demands on the location than did the first method. The bomber should be well within the hangar, in the position shown in Fig. C_a-1.15. Spotted in this way, structural parts of the hangar are available for the suspension of plumb-lines ahead and behind the aircraft. The nosewheel should be left straight.

The airplane is placed on jacks -- four are sufficient -- one under each wing and two on the fuselage near the nosewheel. Blocking should be placed under the tail-skid to prevent the plane from falling off the jacks in the event of inadvertent tail-heaviness.

The plane should be roped off and posted with "Do Not Enter Rear Bomb-Bay" and "Keep Off" signs to keep unauthorized personnel from entering the plane and causing it to tilt slightly during the surveying operations.

Art. C_a-1.04. Leveling Procedure. The method of leveling the airplane and locating the XY or horizontal plane of the master turret is given in Art. D-2.10. The reference plane of any other turret may be found by applying the method of Art. D-2.13.

Art. C_a-1.05. Determination of Z-Axes. The method developed in the fall of 1944 is given in Art. D-2.14. An alternative method, also applicable to the type PB4Y-2 airplane, is described below:

By means of a plumbline fixture* fasten a plumb-line to some non-elevating part of the forward crown-turret as shown in Fig. C_a-1.16, and point the guns abeam; the line should be about a foot off-center, with the bob about 1/16 inch from the deck. Move the turret in azimuth, and at about 120° intervals mark the position of the bob on the deck, giving three points. Erect perpendicular bisectors to the sides of the triangle described by the points; the intersection of the bisectors will be the approximate location of where the Z-axis pierces the deck. (The location is only approximate because of the inaccuracy of the bob-point transfer and the difficulty of accurately drawing the perpendiculars).

Now adjust the plumb-line fixture so that the bob hangs over the approximate center, Fig. C_a-1.16. Set a transit at Position 1 (Pos. 1) on the hangar deck with the telescope projecting through the rear escape hatch, Fig. C_a-1.17. Level the transit, sight on the plumb-line hanging from the forward crown-turret, putting the vertical hair on the line, and set the transit azimuth to zero. Rotate the turret about 180° and sight again. If the plumb-line has moved to one side of the vertical hair, measure the azimuth angle on transit, and turn the transit half of this amount in the direction of movement, and zero the azimuth circle again. Next move the plumb-line into coincidence with the vertical hair by adjusting the plumb-line fixture. Rotate the turret 180° again, and repeat the

* This fixture consists essentially of a clamp and a cord-holder; the cord-holder can be moved in two perpendicular directions to shift the cord position fore-and-aft or athwartwise.

operation of shifting the plumb-line until it stays on the vertical hair over 360° rotation. This position of the plumb-line defines the Z-axis or an extension of it. Leave the plumb-line for the forward crown-turret in this position. Repeat the procedure for the rear crown-turret with the transit still at Pos. 1. Leave the plumb-line for the rear crown-turret in this position.

Art. C_a-1.06. Definition of the XZ-Plane. The XZ-plane is defined as the plane containing the Z-axes of the crown turrets. For practical purposes it is also the ("vertical") plane of symmetry of the airplane.

Art. C_a-1.07. Aircraft Geometry. By moving the transit sidewise it is possible to find a position where the vertical hair of the transit falls over both plumb-lines. The plate-bubbles of the transit must be level, of course. Getting the transit into this location is arduous. However, once completed, the transit telescope lies in the XZ-plane, and may be used to mark points in this plane.

Certain points in the interior of the aircraft may now be established. Point P_1, Fig. C_a-1.18, on the step to the pilot's compartment is now marked; and by dumping the telescope, point P_2, Fig. C_a-1.19, on the frame under the tail-turret may be marked. After marking, center punch and drill with a No. 60 (0.040 in.) drill. Check the position of the holes from Pos. 1 with the transit. Unfortunately no external marks can be made from the setup at Pos. 1, so the transit may now be removed.

Stretch a chalkline or mason's-cord (0.050 in. diameter) between the holes at P_1 and P_2. This line now lies in the XY-plane. From this chalkline two plumblines A and B are attached so that they will pass through holes in the catwalk of the bomb-bay. Adequately weighted drip-pans* are placed under eaeh line, with the plumb bob about 1/8-inch above the

* These drip-pans should be laid on the deck up-side-down, and the top surface should be clean and covered with (machinist's) lay-out dye such as Dy-Kem or Miccro Supreme.

drip-pans. These plumb-lines are in the XZ-plane, now materialized on the outside of the airplane.

Set up the transit at Pos. 3, about 15 feet to starboard and about in line with the escape hatch so that both plumb-lines A and B may be seen. After leveling the transit plate, sight on line A, depress scope and mark points 1 and 2 on the line of sight about one foot apart on the drip-pan. Scribe the line 1-2. Now sight on line B and spot points 3 and 4 on the drip-pan, and draw line 3-4. Move transit to Pos. 4, about 20 feet to starboard and a little back of the wing trailing edge. After leveling, sight on line A and get points 5 and 6 and scribe line 5-6; in similar fashion get line 7-8 from plumb-line B.

The point A_o defined by the intersection of lines 1-2 and 5-6 is on the intersection of the XZ-plane with the deck, and so is B_o (from the intersection of lines 3-4 and 7-8).

The transit should now be moved to another location, Pos. 4' (not shown), say to the port-side, and the vertical hair put on the plumb-lines A and B and points A_o and B_o for check. If any discrepancy exists -- someone may have moved the drip-pan, or there may have been an error in scribing the lines defining the points A_o and B_o - it must be rectified now. If A_o and B_o are directly below their respective plumb-lines, center-punch them. Leave the transit at Pos. 4'.

Scribe the line segments of A_o-B_o on each drip-pan by stretching a thread over the points A_o and B_o and marking the pan edges, after which a steel straight-edge is used as a guide. Note that this line A_o-B_o cannot be extended forward directly by sighting since the nosewheel is in the way. At A_o construct a perpendicular to the line A_o-B_o, using a trammel bar; do the same at B.

Art. C_e-1.08. Camera Bore-Sighting. Set the trammel bar for 11-1/4 inches, using a vernier-caliper with center-points to get the distance accurately. With A_o as a center establish points C and D, and from B_o get points E and F. Lines C-E and D-F are then in the plane of the guns when the turrets are at zero azimuth. The position of points A_o and B_o should again be checked.

Set up a second transit at Pos. 5, about 20 feet ahead of the plane and on the extension of line D-F. Again this will be a slow procedure. To assist in picking up the aligning points D and F the head of a combination square should be set on the points and sighted upon.

With the transit at Pos. 5, and definitely lined on the marks D and F, other points in the vertical plane may be located, as point K on an accessible but stationary part of the hangar structure, as a rafter or door frame. Drop plumb-line K to hangar deck. Check points A_o and B_o again with the transit still at Pos. 4'. If still in line, proceed.

Move the transit from Pos. 5 to Pos. 6 (opposite Pos. 5) and line upon marks C and E and spot point L on the opposite end of the hangar, and drop plumb-line L. Check points A_o and B_o again with the transit still at Pos. 4'. If still in line, all transits may now be taken down.

Fasten a precision level to the gun-camera tube (mounted on the right gun) as shown in Fig. C_a-1.20, and adjust the gun elevation until the level bubble centers; this is zero gun elevation. Set the elevation vernier of the AZEL to zero.

Insert the special boresighting tool* in gun-camera mounting tube, and rotate turret in azimuth until the vertical hair falls on plumb-line K. This is zero azimuth; set the azimuth vernier of the AZEL to zero. Rotate turret 180° in azimuth by the AZEL ring; the vertical hair of the bore-sight tool should now fall on plumb-line L to the rear.

Sight on plumb-lines K and L while running the guns in elevation to check any deviation.

Secure the camera-mount on the gun-camera tube so that the top plate is level fore-and

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* This bore-sighting tool, not previously described, consists of the regular 0.50 caliber bore-sighter and an adapter -- a bushing -- that fits into the camera lens-holder.

aft and athwartwise. Secure camera bracket to camera before bolting bracket to top plate of gun-camera mount. Insert the bore-sighting tool in the camera lens-mount and adjust the camera so that plumb-lines K and L are on the line of sight.

Art. C_a-1.09. Gyro Alignment. The gyro unit as furnished for aircraft installation consists of two parts, (1) the sub-bedplate to be bolted to the deck, and providing support for (2) the main bedplate on which are mounted two gyroscopes, a camera and a lampholder. These two parts may be distinguished in Fig. B_a-1.05. Since the two gyroscopes are carefully aligned to each other, they should not be removed from the main bedplate. The two gyroscopes as a pair need aligning to the axes of the aircraft, and this is done by properly orienting the main bedplate, as described below.

Art. C_a-1.10. Bedplate Alignment. The sub-bedplate is a U-shaped aluminum casting securely fastened to the deck by several 3/16-inch through-bolts. The open end of the U faces forward, and the legs are placed approximately parallel to the X-axis.

The main bedplate carrying the two gyros, camera and lamp is installed as a unit. This bedplate, also an aluminum casting, is supported about 1/2 inch above the sub-bedplate by means of three leveling screws. Lockscrews are provided to prevent the leveling screws from backing-off once their "level" has been determined.

Two alignments are necessary: the first is to the X-axis, the second to level. Because one adjustment affects the other, it is necessary to go from one to the other.

The X-axis alignment of the main bedplate is obtained by measuring from the slot along its middle rib or the ground-stock bar in the slot to a line swung by a transit adjusted to have its line of sight parallel to the X-axis of the aircraft. Measurements may be made with an extension micrometer which is adjusted to measure exactly the same distance to each end of the slot from the line. Lateral setscrews in the holes in the casting are adjusted with respect to the leveling screws to swing the main bedplate into position.

After approximate alignment to the X-axis has been established, a small machinist's level is placed on top of the dial on the horizontal gyroscope and the leveling screws are adjusted until the vertical axis of the dial is in the true vertical direction for all angular positions of the dial. A check on the X-axis alignment is made at this point; alternating with the leveling procedure from the top of the horizontal gyro dial the set screws for the X-axis alignment of the main bedplate and the lock nuts on the leveling screws on top of the casting are tightened. Final check of the X-axis alignment and the verticality of the axis of the horizontal gyroscope dial should follow the final positioning of the setscrews and lock-nuts. These adjustments are all that are required to establish the orientation of the gyroscope system in the aircraft.

The camera and the lighting fixtures are rigidly mounted on the bedplate and require no further adjustment.

Identical wiring is used throughout the construction and all gyroscope connectors are AN standard. An outer housing or cover is necessary to protect all the working parts of the gyroscopes, dials, lights and camera.

Art. C_a-1.11. Control Units in Fighter. Since various fighters are used, no specific installation can be described. For a given fighter project the units necessary are decided upon by the Project Engineer, after which the Weight and Balance Officer is consulted to decide where and how the units may be disposed in the fighter. Most of the equipment can generally be located near the fuselage acdess hatch.

The four basic units needed in the fighter are the FLINK, the FLINK conversion unit (FCU), the tuning fork inverter (TFI) and the automatic-manual box (AMB). The first three must be in the locations designated by the Weight and Balance Officer, and should be reasonably accessable and shock-mounted. The AMB is a small, light control that must be within easy reach of the pilot. Fig. C_a-1.21 shows a typical installation.

Art. C_a-1.12. Focusing Devices. Difficulty is experienced in focusing A4 and GSAP cameras when they are to be used for photographing instrument dials. The lens-system as supplied is set for photographing objects at "infinity"; subjects at close range can be brought into focus if the lens is moved forward. The problem is to determine the proper lens position. Several solutions are described in Art. E-5.06, "Airborne Manual, 1945", and another is presented below.

The usual procedure in focusing is to substitute a ground glass or its equivalent for the film, and adjust the lens position for sharp definition. Neither the A4 or GSAP cameras are so constructed that this is a feasible procedure, for it is impossible to conveniently view the ground-glass image. In consequence an alternate method was devised, in principle the reverse of the usual method. A piece of film bearing a sharp pattern is inserted at the film gate, and illuminated from the side; the image on the film is thus projected through the lens. A white card is held in front of the dial to be photographed, and the lens is adjusted until the projected image is in sharp focus on the card. It should also be noted that the projected image shows the field coverage.

The focusing device for A4 cameras is a small transparent plastic block, housing five 3-volt instrument lights, as shown in Fig. C_a-1.22. These instrument lamps illuminate areas at the center and corners of the focusing film cemented or taped to the front surface of the block. The block assembly slips into the film space of the camera after the pressure plate clamp has been released and the pressure plate removed. The pressure plate clamp is then engaged to hold the block in place and locate the focusing film in the normal film plane. The brass springs on the rear of the block provide spring pressure to ensure positive location and also act as a ground return for the lamp supply current.

The focusing device for the GSAP camera is contained in a film magazine with one 6-volt lamp providing the illumination, as shown in Fig. C_a-1.23. Operation is similar to that for the A4 camera.

CHAPTER C_a-2

ELECTRICAL CABLING IN BOMBER AND FIGHTER

Art. C_a-2.01. Bomber, PB4Y-2, AT 24. All references in this article are to Fig. C_a-2.01, the bomber cabling print. From this it is seen that 28 volt direct current enters the SU from the No. 2 generator bus through an AN 3102-16-9P connector. The No. 2 generator has been isolated from the main power bus; its sole function is to supply the SU with power. The TFI directly below the SU supplies 110 volt alternating current through an AN 3106-16-9S connector.

The SU handles four turrets of two cameras each, and nine spare cameras in addition, three of which were formerly the tri-cameras. To facilitate handling of cameras, a system of junction boxes and patch panels was built; all cameras are connected to junction boxes. These junction boxes are of two types, turret and camera, and are located at strategic points throughout the aircraft so that no camera cable need be run more than a few feet to tie into the synch system. Typical junction boxes are shown in Figs. C_a-2.02 to C_a-2.04.

The junction box layout is as follows:

1. Six turret junction boxes (Fig. C_a-2.02), one at each of the six turrets. Each of these junction boxes handles two 35-mm cameras; there is but one cable tieing each box into the synch system.

2. Six camera junction boxes (Figs. C_a-2.03, C_a-2.04) in the following locations:

    a. One between the tail turret and the waist turrets.

    b. One between waist turrets and aft crown turrets.

    c. Two on forward wall of bombbay: one to starboard - one to port.

    d. One on flight deck near radar range rack.

    e. One in nose turret compartment under the flight deck.

    Each camera junction box is wired to handle two cameras. However, each camera requires its own cable to the SU so that only six cameras in total can be run from these junction boxes even though there are twelve available outlets.

Referring to Fig. C_a-2.01 again, it is seen that the camera junction boxes are directly connected to the SU through AN 3102-18-8P plugs. However the turret junction boxes are cabled to the patch panel, and patched from there to the SU. The patch panel is so arranged that any four of the six turret junction boxes may be patched into the four available turret outlets of the SU. Patch cables are provided for this panel, as shown in Fig. B_a-2.01. All connectors for turret junction box and patch panel cables are AN 3102-22-19P.

The shutter opening time of each camera of the system is recorded on an oscillograph tape; this is done by means of a small commutator on the shutter (shutter contact) which sends a ground pulse back to the SU through the camera cable. Each pulse from the various cameras is then brought through another patch panel similar to the turret patch panel which allows any twelve of the seventeen camera shutter pulses to be recorded on the twelve-channel oscillograph. The camera shutter pulses are taken from the SU to the patch panel through an AN-3102-28-16P connector. The oscillograph is also powered from the SU through an AN-3102-18-8P so that it operates synchronously with the cameras.

In addition to the junction boxes described above there are also the "reference turret junction boxes". The trigger connections necessary for the flashlighting for instrument photography are made here. The Main Flash Unit (MFU) is cabled from the SU through an AN 3102-18-12P. The BLINK is cabled from the SU through an AN 3102-20-16P. The MCU is connected to the SU through an AN 3102-28-16P connector.

The MCU has several connections as listed:

1. Cable to SU through an AN 3102-28-16P.
2. Cable for radar range indicator light through an AN 3102-20-16P.
3. Cable to junction box through an AN 3102-20-1P. This junction box is the terminus for the cables from five stations -- nose turret, pilot, flight deck, waist turret, tail turret -- where there are outlets into which the Obs may connect his OCU.

Art. C -2.02. Fighter. Appendix B_a on BLINK-FLINK design details the workings of the fighter electrical system. Fig. C_a-2.05, the fighter cabling diagram, indicates the cables needed to put the system into operation.

A complete outline of electrical cabling for a specific fighter is not given, for aircraft of different types are used. Obviously the physical installations in fighters will vary with the aircraft type and the nature of the project; in consequence only suggestions of a general nature are listed below in order of importance:

1. All cables must be rigidly fastened throughout the aircraft. A cable should never have enough freedom to endanger the controls of the aircraft.

2. All necessary structural changes (such as needed when adding wing tights for ranging) should be OK'd by the Engineering Officer and the work done by the qualified men (metal shop, machine shop, etc.).

3. Change in position of any equipment or removal of equipment in the plane to make room for wiring must be OK'd by the Engineering Officer.

4. Under no circumstances should the wiring in the aircraft be altered by the addition of the BLINK-FLINK equipment unless requested by and OK'd by the head of the Fire Control Department.

DUTIES OF PERSONNEL

CHAPTER D_a-1

DUTIES OF THE ELECTRICAL TECHNICIAN

Art. D_a-1.01. Introduction. At the start of any aerial assessment project, the Project Officer and Chief Mathematician of Fire Control determine what data are needed. In the light of this the Mechanical and Electrical Engineers of the Fire Control Department decide on the necessary equipment. It is the Electrical Technician's duty to see to it that all cameras are wired for operation and functioning properly after they have been installed by the Mechanical Engineering Group. This includes all electrical units, as SU, MCU, MFU, OR -- whatever is necessary to fulfill the project requirement.

Art. D_a-1.02. Typical Example of Camera Wiring. Consider an assessment project involving sight- and gun-cameras in the forward crown-turret, an AZEL-camera and a gyro-camera. Referring to the block diagram, Fig. C_a-2.01, the ET makes the necessary cables to connect each camera to its nearest junction box. The sight- and AZEL-camera can both be connected to the spare camera junction box just outside the forward crown-turret. The gun-camera must be connected to the reference turret junction box mounted on the turret. This is done because the AZEL-camera photographs with the aid of the high-speed flash unit; the latter is triggered through the reference turret junction box. The gyro is directly connected to an SU camera plug since the gyro and the SU are but about six feet apart. Having made these connections, the ET checks the SU to see which of his camera outlets was wired to the spare camera junction box at the forward crown-turret. Knowing this, he turns on the corresponding camera switch in the SU. He also turns on the camera switch corresponding to the plug being used for the gyro. He then makes a patch connection on the turret patch panel connecting the forward crown-turret outlet to any of the four SU turret outlets. Finally, he turns on the turret switch corresponding to the patch connection just completed. In order to have these cameras recorded on the oscillograph, he patches on the galvanometer patch panel each camera just connected to an available galvanometer. This completes the electrical wiring necessary for operation.

If a similar installation is to be made on a transient aircraft, the portable or Mk IV system would be employed. In making the installation, the Electrical Engineer, the Project Engineer and the ET would have to determine the most convenient location of the units for operation during flight. The ET would cable the cameras according to the block diagram, Fig. C_a-2.01, and refer to Section C_a.

After an installation has been completed, the ET should put the entire system into operation and check the primary control functions of the SU, viz., READY, START, STOP, TIMING and CATALOG. If any of the sequences fails, the ET would refer to Section E_a for aid in determining the nature of the difficulty. If the control sequence functions properly, the ET is ready to electrically synchronize the cameras, as described in the following article.

Art. D_a-1.03. The Preflight Check. The Preflight Check investigates the phasing and synchronization of all cameras prior to an actual flight, and provides the opportunity to "tune" the synchronizing and camera control system to insure satisfactory operation. The Preflight Check is the most important duty of the ET.

This Check Procedure assumes that the initial synchronizing adjustments have been made in a bench-check of each camera as given in Art. E_a-1.06. The ET should also be thoroughly familiar with Chapter E_a-1.

The Preflight adjustments are made (1) in terms of the equipment permanently installed in the airplane, and (2) test equipment consisting of a cathode ray oscillograph and an electronic switch. The aircraft electrical system is connected to an external rectifier, set to supply direct current at 27.5 - 28.5 volts under load.

The order of procedure follows:

1. The unloaded cameras are given a 15-second warm-up run, after which a 10-second run is recorded on the oscillograph. This record film is developed and used as a reference to suggest the camera adjustments.

2. The forward crown gun-camera trace is compared with the timing trace (see Fig. D_a-1.01, sample tape and film). This camera has been designated the master camera in the permanent PB4Y-2 installation. The designation of a master camera may vary according to the data called for by the particular project, but the alignment procedure is the same as outlined here. Note that the timing marks appear on the film Fig. D_a-1.01 (b) as sharp, clear dots. It is necessary that the timing light be flashed when the film is not in motion. On the oscillograph trace, this means that the break-point of the timing mark be within ± 0.007 seconds of the shutter opening point. Since the mechanism of the camera is such that the film is stopped when the shutter is open, this will insure that the timing mark is flashed when the film is motionless. If the timing- and gun-camera traces are out of phase by more than the allowable 0.007 sec, the gun-camera must be shifted in phase until it matches the timing mark. This phase shifting is described in Step 3.

3. The rear section of the camera motor housing is removed. This exposes the Lee governor, shown in Fig. D_a-1.02, which rotates with the motor shaft at 3600 rpm. Since the shutter is geared down to 1/3 of that speed, or 1200 rpm, any angular change in the shutter would cause three times the angular change at the Lee governor. For purposes of explanation, let us assume that the gun camera shutter has to be moved 0.007 sec to phase it with the timing mark. At 20 revolutions per second, the shutter speed, 0.001 sec, corresponds to 7.2°. Therefore, 0.007 sec represents an angular motion of 7.2° times 7, or 50.4°. At the Lee governor this would represent 3 times 50.4° or 151.2°. Therefore, to phase the shutter with the timing, the Lee governor must be rotated 151.2° while the cam (Fig. D_a-1.03) on the shutter shaft which controls the synch contacts is held stationary. The Allen head adjusting screw on this cam can be reached through the access plug shown in Fig. B_a-2.02. If it is desired to move the gun-camera forward in time (to the left on the tape), the Lee governor is rotated clockwise while the cam is held stationary; and if it is desired to move the camera phase backward in time, the Lee governor is rotated counter-clockwise while the cam is held stationary. Clockwise and counter-clockwise motion are determined when viewing the governor from the angle shown in Fig. D_a-1.02.

4. After the camera is adjusted to the timing mark from the original test tape, a second tape is run to check the accuracy of the adjustment. Further adjustments are then made if necessary until the timing and master-camera trace match to within the limits set in Step 1.

5. The cathode ray oscillograph and electronic switch are connected as shown in Fig. D_a-1.04. This circuit enables the ET to view the shutter pulses of two cameras simultaneously. The master camera previously adjusted to phase with the timing trace is permanently connected to one of the viewing traces; while each of the remaining cameras to be adjusted are connected in turn to the other viewing trace. Each camera is then phased to the master camera using the same procedure as described above for the master camera until the camera under adjustment is in phase with the master camera. In making these adjustments, every attempt should be made to adjust each camera to the master to ± 0.001 sec.

6. After all cameras have been adjusted, a third tape is run to check the accuracy of the cathode ray oscillograph adjustments. If this tape shows

any camera to be out of phase by more than 0.002 sec, this camera is phase-adjusted until it matches the master camera.

Care should be taken when making these adjustments that the cam set-screw is loosened sufficiently when making the phase adjustment so that the tip of the Allen head set-screw does not scar the shaft on which it is mounted and that the set-screw is securely locked after the adjustment is made. If this set-screw is not secured properly it will cause the camera to vary in phase continually as the cam slips on the shaft.

The Preflight Check as detailed above was made on cameras without film load. The film load, although not great, may cause a phase difference between any camera and the master camera of the order of 0.002 - 0.003 sec. Since an oscillograph record of the cameras under load is available after the first flight, Step 1 may be started with this record.

If any camera fails to synch on a flight, the record for that camera cannot be used for the next Preflight Check. This camera must be re-synched and a new tape run to phase it with the remaining cameras.

On the SU (see Fig. B_a-1.01) there is a phasing control for each camera in the form of a screwdriver-adjustable rheostat. This is a fine adjustment to change the camera phase 0.002 sec. It has been found that the cameras can be accurately phased using the cam-slipping method described above and the fine adjustment is rarely used.

After each flight the ET should examine the oscillograph tape to aid him in determining what repairs will be needed in preparation for the next flight.

Should any camera fail to phase with the master, the synchronizing adjustments of that camera should be checked by the method given in Section E_a. This can be done in the aircraft by removing the entire motor housing from the camera. After the camera has been correctly synchronized, the phasing adjustment should be re-checked.

If any camera fails to synchronize in the preflight checks, it should be replaced and carefully examined for mechanical troubles on the bench. This is usually taken care of by the Mechanical Engineer or the Coordinator.

Art. D_a-1.4. Oscillograph Tape Checking. When the film is developed it must be reviewed with the flight data sheets. The number of runs and duration of each run can be checked on the tape and should correspond to the log kept during flight. If any trouble was encountered during flight the corresponding points in the tape can be marked to avoid confusion. An example of a typical item to be marked on the tape would be an attack during the flight which was stopped without CATALOG due to electrical or mechanical trouble. This can be done by the Coordinator.

After the tape is marked with all pertinent notes from the flight data sheet the ET checks the tape for the following information:

1. Are all traces on the tape sharp, clean, and in their proper places? In Fig. D_a-1.01 (a), several cameras show a galvo with loose suspension giving excess vibration.

2. Do the timing marks occur once per second, and is the correct catalog number at the end of each run?

3. Does each camera hold synch to ± .001? If a camera does not hold synch to ± 0.001 sec it should be checked for mechanical trouble, replaced if necessary or merely adjusted (governor contacts).

4. How long does each camera take to lock into synch? If a camera takes longer than 0.5 sec to get into synch its velocity governor adjustment should be checked.

5. What is the phase difference between cameras and between cameras and timing? Limits of ± 0.007 sec between timing and any camera, ± 0.002 sec between cameras must be maintained, as explained in ET Preflight Check, Art. D_a-1.03.

6. Do any traces deflect so that the leading edge is rounded? If so, the shutter contact for this camera requires cleaning.

CHAPTER D_a-2

DUTIES OF THE COORDINATOR

Art. D_a-2.01. Introduction. Working out a program for the assessment of a particular piece of equipment involves a number of persons who work in the various phases of operation, installation, maintenance, development and assessment. Each individual has responsibilities, but because of small work overlaps, a single person responsible for the correlation of the various phases of the work is needed. This man is the Coordinator. As the assessment work is now laid out, the Coordinator works under the Mechanical Engineering Group and specializes in the photographic requirements of the work.

Art. D_a-2.02. Procedure. The duties of the Coordinator, in order of occurence, are given below:

1. He is responsible for notifying the technicians of the requirements of the project and following up the installation work to see that the various electrical and mechanical units are installed in the minimum of time.

2. After all installations have been made and checked, and the aircraft is ready for flight, it is his duty to see that the members of the flight crew are briefed on the work to be done in the air. One specific item is the ET's Preflight Check. Before any flight leaves the ground, the Coordinator must have the ET's Pre-Flight Check-Off Sheet, Fig. D_a-1.05, signed by the technician who made the check-out. Then the Coordinator himself must make a complete Preflight Photographic Check, Fig. D_a-2.01. This includes checking each camera for lens opening, clean lens, clean aperature plate, secure mountings and finally, loading the camera. A detailed explanation of these checks is given in Art. E-5.07 (Airborne Manual, 1945).

3. After completing his check-out and receiving the OK on the ET's check-out, the Coordinator notifies the Pilot that the plane is ready for flight and distributes to the MCO, Obs and Pilot the proper data sheets to be filled out during the flight, Figs. D_a-2.02 and D_a-2.03. After a flight has been completed, the Coordinator unloads all the cameras, checking them for break-down due to jamming of film. Each roll of film should be properly labeled for development at the Photo Lab. To insure the information necessary for proper development is permanently recorded, the Coordinator keeps a log listing each camera installation. The data included in this log give the type of camera, the type of lens, the shutter opening of the camera, the f-stop of the lens, the type of lighting used, the type of film used and the recommended development for the film. Any break-down or repairs to cameras are listed by date in this log.

4. All films from the flight are delivered by the Coordinator to the Photo Lab for processing.

5. The flight data sheets are gathered by the Coordinator and kept with the preflight data sheets until the processed film is returned.

   Note: Since the oscillograph tape is needed by the ET to prepare for the next flight, it is developed immediately after flight at Armament Test. After the ET has taken the necessary data from the tape for his record, the tape is turned over to the Coordinator to be held with the data sheets until the film is ready.

6. When all the particulars for a given flight have been gathered the Coordinator and the Project Engineer review them. In this review of the flight data the following points should be checked:

   1. Is the photography acceptable? This is best judged by comparing it with the accepted sample films made during installation of the cameras.

   2. Do the timing marks occur once per second; are they clearly and sharply defined?

   3. Are the correct number of catalog marks present after each attack?

   4. Are there any oddities in the sequence of attack which should be noted for the film readers? This can be checked using the flight data sheets.

From the answers to these questions, the Coordinator and Project Officer can determine the amount of work necessary to prepare for the next flight and plans are prepared for that flight. Before this flight can be made, the Coordinator must receive from the men making the necessary repairs their assurance that all repairs have been made and the equipment is ready for flight.

CHAPTER D_a-3

DUTIES OF MASTER CONTROL OPERATOR AND OBSERVER

Art. D_a-3.01. Introduction. The duties of the Master Control Operator and Observer are explained together because their work during the flight is very closely related. As was explained in Section B_a, the MCO is generally the ET and the Obs is the Project Officer. If for some reason the MCO is some one other than the ET, it is imperative that he be thoroughly acquainted with the equipment not just to the extent to the button-pushing knowledge, but knowing at least the main points of the ins and outs of the electrical circuits. Many times this knowledge of operation and theory will save a flight already in the air when some minor difficulty arises.

Art. D_a-3.02. The Master Control Operator. When the MCO takes over the operation of the equipment just before take-off, the system is turned off but the gyros are running for warm-up. The gyros are allowed to run until the pilot is ready for take-off and then they are turned off until the plane is airborne. Once the aircraft is airborne, the MCO turns on the main power switch (28 VOLTS, Fig. B_a-1.01) and the gyros. This puts the entire system into stand-by operation. The MCO, knowing what cameras are to be used for the test, checks the camera switch of the synch system and the patch cables to be sure that nothing has been disturbed since the ET completed his check-up. Turning on the main power switch of the synch system energizes three meters mounted to the right of the synch system, Fig. B_a-2.01, which are used for monitoring. The MCO should check these meters for the following readings to be sure that the system is operating properly:

1. The d-c voltmeter should read $28.5 \pm 1/2$.
2. The d-c ammeter should read 1 ampere immediately after the switch is turned on.
3. The a-c ammeter should read zero.
4. After approximately 20 seconds the time delay of the TFI (Fig. D_a-3.01) turns on the alternating current and the d-c ammeter should read 3.1 and the a-c voltmeter should read 115.

Two disturbances may occur at this time:

a. The TFI may not operate properly, i.e., the time-delay relay fails to operate, the a-c voltmeter shows zero and the master motor operated from the TFI does not run.

b. The master motor may fail to start because of heavy loading, indicated by a high reading on the d-c ammeter (5 to 6 amperes) and a low reading on the a-c voltmeter (60 to 85 volts). In either case the equipment should be turned off and checked.

The most common cause of failure at this point is arcing in the power vibrator in the TFI. Many times simply turning the equipment on and off at the main power switch stops the arcing; however, if the arcing persists the vibrator should be replaced. This may be done in the air if the MCO is an ET. If the MCO is not acquainted with the system no repairs should be attempted in the air; rather the flight should be cancelled and returned to the base.

If the voltages and current check, the MCO allows the system to run and proceeds to erect the gyros. Although this sequence has been detailed in Art. B_a-2.05 it is repeated here for convenience:

The six-position rotary switch (Fig. B_a-1.04) controls the erection system and should be in No. 1 position during warm up of the gyros. Several minutes before the first attack, the switch should be advanced tc the No. 2 position, remaining there until one of the pairs of indicator lamps marked HOR. STAB. ERECT goes out. The switch is then advanced to the No. 3 position and remains there until the remaining pair of indicator lamps goes out. The switch is kept at the next or No. 4 position until the MCO learns from the Obs that the fighter plane is in attacking position and is ready to begin the attack. Correct gyro operation at this point is indicated by the <u>flickering</u> of the SOLENOID ERECT indicators. (If these indicators glow <u>steadily</u>, the first four switch operations should be repeated.) The MCO now advances the switch to the No. 5 position for one-half second, and then to No. 6 position for the rest of the attack.

This procedure is repeated for each attack. However, for attacks other than the first, the first four switch positions may immediately follow the completion of the previous attack. In other words, the gyros must be operating in the No. 4 position when the attack is about to start.

When the Obs indicates that the planes are in position and action is imminent, the MCO dials 1 on the MCU to indicate the first attack. He then presses the READY button which completes the power circuits in the auxiliary units such as the flash unit and the BLINK. The READY button also lights a green light on the OCU and tells the Obs that the cameras are ready to record.

Careful handling of the sequence of operation at this point is required of the MCO. He must erect the gyros, take a zero picture of the gyros and READY the camera synch system within the space of a few seconds. The following order of events was found workable:

1. Erect the gyros through position No. 4;
2. Receive word from Obs that he is ready to start recording;
3. Complete gyro zero shot positions Nos. 5 and 6;
4. READY the synch system.

With the system readied the MCO is finished until the next attack.

Art. D_a-3.03. The Observer. The Obs takes control and pushes the START button on the OCU when the recording is to be made. (Note both the Obs and MCO have a STOP button with which the sequence can be stopped immediately if any electrical, mechanical, or photographic trouble arises.) If all goes well the recording is stopped with the CATALOG button by the Obs. This enters on the film the attack number in the form of a single dot, as shown in Fig. D_a-1.01(b). On succeeding attacks the CATALOG light marks 2, 3, 4, etc., dots in quick succession on the film.

THEORY AND MAINTENANCE OF SYSTEM UNITS

CHAPTER E_a-1

SYNCHRONIZING AND CAMERA CONTROL SYSTEMS, Mk III AND Mk IV

Art. E_a-1.01. Introduction to the Mk III and Mk IV. Certain improvements over the Mk II system have been incorporated in the Mk III and Mk IV systems (see Drawings Nos. P28E-41-A31 through T175, available at Evanston or Patuxent) to increase the accuracy of the data and at the same time to simplify assessment procedures. These improvements include the following:

1. Replacement of vibrator with electrically driven tuning fork, giving a frequency standard accurate to one part in 10,000;
2. Both A-4 and GSAP cameras run at 20 frames per second;
3. All camera shutters operate simultaneously within a tolerance of ± 0.002 sec;
4. A continuous record of instant of maximum shutter opening is obtained, readable to 0.001 second. This record also contains a record of the timing and cataloging indications which appear on the film;
5. Neon gas lamps fired with a short duration electrical impulse mark the film distinctly on one frame, giving positive identification to the timing and cataloging marks;
6. Flash photography is employed to record scale and vernier reading of fast-moving dials.

Art. E_a-1.02. Standard Frequency Source. The frequency standard (Fig. E_a-1.02) of the system is a 60-cycle, temperature compensated tuning fork (Fig. D_a-3.01) accurate to one part in ten thousand. The output of the fork is amplified by means of vibrators and transformed to supply 110 volt a-c power. Two synchronous motors are driven from this supply. One is a synchronous timing motor in the oscillograph recorder unit which produces 0.01 second timing lines on a continuously moving tape. The other is a 3600 rpm master synchronous motor which is geared down to operate a bank of contacts controlling the camera drive motors and to operate a switch which initiates the film timing impulses, shown in Fig. E_a-1.01.

Art. E_a-1.03. Oscillograph Recorder. In the oscillograph recorder unit, Fig. E_a-1.03, a permanent record of the instant of maximum shutter opening of all cameras is made by the deflection of light beams on sensitized paper. The impulse which deflects each galvanometer light beam occurs when the center of the shutter opening reaches the center of the frame which is being exposed and contact is made between a brush and a commutator segment rotating with the shutter. The tape record contains the absolute time base, a trace of each camera and a trace showing timing and cataloging impulses; a sample is shown in Fig. D_a-1.01 (a). The paper-drive motor in this unit is controlled in the same manner as the camera motors, and in consequence a 100-foot spool of paper runs just as long as a 100-foot roll of 35-mm film.

Art. E_a-1.04. Timing and Cataloging. The timing and cataloging lamps are small neon filled lamps flashed by the short duration surges produced by passing current through an inductance and breaking the circuit suddenly. Timing impulses, and hence timing marks, occur once a second (or once every 20 frames) while the cameras are running. The same lamps give the cataloging marks at the end of each run. The cataloging marks occur at the rate of five per second, and are further differentiated on the film, see Fig. D_a-1.01 (b), from the double-dot timing marks by appearing as single dots. The oscillograph record shows the length of time the circuit is closed as well as the surge at the break, and this closed period differs between timing and cataloging.

The timing and cataloging circuit is shown in Fig. E_a-1.04. All lamps are in parallel across one coil designed for the maximum number of lamps that may be required. When fewer lamps are required, dummy lamp loads may be used to prevent overloading and consequent blackening of the lamps. A timing hold-up relay operates at the first catalog pulse and transfers the coil circuit from one set of lamps in the cameras to a dummy set within the SU during the period that the cataloging flashes are occurring. This produces the single cataloging dot on the film.

Art. E_a-1.05. Master Contactor. The master contactor shown in Fig. E_a-1.01 consists of a row of contacts actuated by one cam mounted on a shaft which is driven at shutter speed by the a-c synchronous master motor. Corresponding contacts of all pairs open and close at the same time, and each camera is tied to and controlled by a pair of master contacts. A timing cam is geared to the same shaft through a 20:1 reduction gear. This cam initiates the one-second timing marks which appear on the film every 20th frame.

Art. E -1.06. Camera Control. Twenty frames per second was taken as a more desirable camera speed than twenty-four frames per second since it simplified plotting data. All cameras are driven synchronously to furnish this film speed.

Cameras are controlled so that they operate synchronously from a master motor-driven bank of contactors. This is accomplished by applying to the d-c series driving motor accurately timed, constant amplitude pulses capable of being automatically varied in duration to provide the average voltage required to drive the camera motors at 3600 rpm. The master contacts are geared down to 1200 rpm and similar contacts mounted on each camera motor, Fig. D_a-1.04, are also geared down to 1200 rpm, the speed of shutter rotation. The contacts are so connected, Fig. E_a-1.05, that pulses result when corresponding contacts are simultaneously closed to short out a resistance. All contacts are adjusted to be closed for 180 degrees of revolution of the eccentric cam which operates them.

Contactor action is described in Art. E-1.02 of the "Airborne Manual, 1945". The action is such that there is only one relative position of the two (contactor and motor) cam shafts at which control occurs. By operating the master contactor shaft at the desired shutter speed and operating the camera motor contacts from a shaft geared 1:1 with the shutter, the camera motor speed is controlled to drive each shutter synchronously with its master contacts. The shutter opening or phasing of each camera may be made to occur in any desired angular position by slipping the cam on its shaft. Thus all cameras are lined up with each other, or phased, so that their shutters are open simultaneously.

The voltage pulses fed to the motor occur twice for each shutter revolution. The fixed beginnings of the pulses occur when the master contacts close and the varying terminations of the pulses occur when the motor contacts open. This varying duration is the result of the motor's hunting about a phase position. The extent of the hunting may be objectionable because the controlling action occurs at the relatively slow rate of once each $1\frac{1}{2}$ revolutions of the motor shaft. To reduce the hunting to a minimum, a centrifugal governor is connected in series with the contactor circuit, Fig. E_a-1.06. Governor action is fast, responding to changes in velocity and superimposes on the contactor pulses the high frequency pulses which are a result of the vibrating contacts shorting out a low resistance, Fig. E_a-1.07. This governor is set so that when it is rotating at 3600 rpm its vibrating contacts are closed for longer periods than they are open, in order to keep at minimum the power dissipated in the resistor. With velocity control, hunting is limited to about $\pm$ 7.2 degrees or 0.001 second. The pulse shape is shown in Fig. E_a-1.09.

The complete motor control circuit is shown in Fig. E_a-1.08. The acceleration governor, G_a, serves to accelerate the motor rapidly by allowing full voltage to be applied until its contacts open at about 3350 rpm when the synchronizing circuit takes control.

Synchronous operation of GSAP cameras is achieved by placing the motor in a seperate unit and driving the camera with a flexible shaft. This arrangement makes it possible to use a motor powerful enough to drive two cameras. The rebuilt GSAP cameras, like the A-4's, are equipped with shutter contacts and neon timing and cataloging lights.

Art. E_a-1.07. Flash Photography. The details of this are given in Chapters E_a-2 and E_a-3, but a brief description at this point will be worthwhile. By flash photography is meant the taking of a picture when the subject is illuminated by a high intensity short duration light (the flash) while the camera shutter is open. It is the duration of a flash of proper intensity and not the shutter angle that controls the amount of light entering the camera; the only demand on the shutter is that it be completely open during the flash period.

Flash photography is employed for photographing instrument dials. The flash for one or several cameras is initiated by triggering from a camera designated the master camera, whence simultaneous exposures are made by the several cameras even though the shutters are not exactly phased. As mentioned before, the shutter must be completely open when the flash occurs. The necessary accuracy of shutter phasing is therefore dependent on the shutter angle, becoming more critical with smaller shutter angles. The shutter angle may be large unless the camera location is such that an excessive amount of extraneous light strikes the lens.

Art. E_a-1.08. Step-by-Step Operation of Circuit.

1. To place the equipment in operation, close 28 VOLTS switch S-1. This results in the following:
    a. 28 VOLTS ON lamp in SU glows;
    b. Thread bus is energized;
    c. POWER lamp in MCU lights;
    d. FORK ON lamp in TFI lights.

        After a time delay of about 30 seconds:

        1. AC ON lamp in TFI lights;
        2. AC FUSE lamp in SU glows;
        3. Relay Y pulls up, removing ground from chain ground shorting bus;
        4. Master motor in SU starts;
        5. Timing motor in OR starts.
    e. The pilot light in the MFU lights, the inverter starts, and the tube

filaments are energized. Relay 1 is energized, removing the ground from the chain ground shorting bus;

f. The pilot light in the AFU lights, the inverter starts, and the tube filaments are energized.

Relay 1 is energized, removing the ground from the chain ground shorting bus;

g. 28 volts direct current is available in the OR for manual operation;

h. Tube filaments in BLINK transmitter light.

2. Operate dial to proper attack number

a. Off normal contacts place ground, through normally closed contacts of relay AA, on dial ground bus.

3. Operate READY push-switch.

a. READY lamps on MCU and OCU light. This circuit is from positive battery through the READY lamps (both are in parallel) through normally closed contacts of relay CC, through normally open holding contacts of relay BB and through the STOP switches to dial ground.

b. Relay BB (battery connected) pulls up, receiving dial ground through READY push-switch and locking to dial ground through its own contacts, through the STOP push-switch in the MCU, through the STOP push-switch on the OCU, to the dial ground on the normally off contacts on the dial.

1. Another pair of normally open contacts of relay BB close dial ground to normally open contacts on relay CC, i.e., dial ground is shifted to ready ground.

2. Relay X (battery connected) pulls up from ready ground closing circuit from ground through timing cam pulsing contacts to relay U which is battery connected.

a. The timing indicator in the MCU blinks.

b. The catalog and timing buses are energized.

3. Ready channel in BLINK transmitter is energized.

4. Relay 3 in the MFU is energized, applying the high voltage to the 816 rectifier tube and charging the energy storage capacitors.

5. Relay 3 in the AFU is energized, applying the high voltage to the 816 rectifier tube and charging the energy storage capacitor.

4. Operate START push-switch on either MCU or OCU (they are both in parallel).

a. Relay CC (battery connected) pulls up, receiving ready ground through the START push-switch and locking up through its own contacts.

1. Normally closed contacts open, extinguishing READY lamps on MCU and OCU.

2. Break-make contacts remove control of dial release magnet, DD, from the DIAL RESET switch, and close the circuit between the GOOD RUNS counter and the CATALOG switch (on OCU only).

b. Relay EE (battery connected) pulls up, receiving ready ground through the START switch. This closes normally open contacts placing positive battery on the camera motor bus.

1. Relay T (ground connected) pulls up, receiving battery from the camera motor bus. This closes the circuit from the timing cam pulsing contacts to the SECONDS counter.

2. Relay A (ground connected) pulls up, receiving battery from the camera motor bus.

a. CAMERAS ON lights in MCU and OCU glow, receiving ground through normally open contacts of Relay A.

3. Relay AA (ground connected) pulls up, receiving battery from the camera motor bus.
   a. The make-before-break contacts transfer the dial from the main holding ground to the chain ground circuit through contacts of relay A.

c. Start ground is supplied to BLINK transmitter.

d. Relay XX, in parallel with relay EE, pulls up.
   1. Ready ground is removed from BLINK transmitter.
   2. Paper drive motor in OR starts.

The trigger circuit in the MFU is triggered by the camera shutter contact discharging the trigger energy storage capacitors through the primaries of the midget ignition coils. This triggers the flash lamps, discharging the high voltage energy storage capacitors through the lamps.

The trigger circuit in the AFU is triggered by a pulse from the MFU, discharging the trigger energy storage capacitor through the primary of the midget ignition coil. This triggers the flash lamp, discharging the high voltage energy storage capacitor through the lamp.

5. Operate CATALOG push-switch on OCU.
   a. Relay V (battery connected) pulls up, receiving start ground through the CATALOG switch contacts and holding ground through normally open contacts of dial release magnet.
      1. Normally closed contacts open, removing ground timing pulses from the BLINK.
      2. Break-make contacts remove the firing impulses from the timing bus and place them on a dummy lamp load.

b. Relay DD (battery connected) pulls up, receiving start ground through the CATALOG switch contacts and holding ground through its own normally open contacts.

1. The CATALOG indicator lamp in the MCU blinks.

2. Relay S (battery connected) operates from the dial ground pulsing contacts.

   a. Firing impulses are put on the catalog bus.

   b. Ground pulses are put on relay V.

3. Catalog ground is supplied to BLINK transmitter.

c. The dial comes to rest opening the ground circuit through contacts A in the SU and AA in the MCU.

d. The end of the last dial pulse opens the ground circuit through S contacts and power is cut off.

e. Relays B,C,D,E,F,G,H,J,L,N,P, are fuse relays. Their circuits are arranged so that if a fuse should blow, the circuit is then made through the relay coil. This pulls up the relay, closing contacts to ground and thereby grounding the chain ground shorting bus. This bus terminates at the battery side of relay A. If grounded, relay A releases, thereby breaking the holding ground for relays EE, CC, and BB.

Art. E_a-1.09. Camera Motor Adjustments. The governor, Fig. D_a-1.02, is one of the two-speed type with two sets of contacts, one set, G_a, connected to the inner slip rings and the other set, G_v, connected to the outer slip rings. The acceleration governor*, G_a, with 28-volt on pin H (+) and pin F (-), should be adjusted for 3320 to 3350 rpm, with

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* This governor allows full line voltage for starting, after which the voltage is periodically limited by the resistor R-1.

the aid of a stroboscope. A check on this adjustment is to set the stroboscope on the 60-cycle line frequency and observe the motor. It should appear to be rotating counter-clockwise at about 4 rps. With this setting, the lock nut should be tightened and glyptoled.

The second adjustment is that of the contactor. This may be accomplished by connecting an ohmmeter across a pair of contacts and rotating the motor shaft by hand. Proper adjustment is that which indicates that the contacts open at exactly $1\frac{1}{2}$ governor revolutions after they close. The lock nuts should then be tightened and glyptoled.

The third adjustment is that of the high speed, or velocity governor, G_v, made with the motor connected into the control circuit, Fig. E_a-1.08. This requires a pair of standard contacts driven at 1200 rpm with the center arm connected to the ground side of the 28-volt supply. The contact arms are connected to pins A and B of the camera connector. With an oscilloscope, view the voltage across the resistor R-1. A hole is provided in the motor housing through which a test-prod may be inserted to reach one side of the resistor, the other side being ground.

The motor should operate at 3600 rpm and pulses should be seen on the oscilloscope screen. At 3600 rpm the pulse shape is affected by the governor adjustment in the range between the settings where the contacts are completely open and where they are completely closed. If the vibrating contacts are completely open, the pulse will be wider and have a smaller amplitude than when the contacts are completely closed. For the extreme conditions of completely open or completely closed contacts no superimposed pulses of higher frequency are present. For the intermediate range high frequency pulses will be visible and the correct setting is that which makes the broken line at E, Fig. E_a-1.09, appear to be about 3 times as heavy as the line at E_g.

Art. E_a-1.10. Phasing Adjustment. The threaded cam adjusting hole plug and the back of the motor housing must be removed to slip the eccentric cam on its shaft. The hole provides a means of reaching the cam set screw with a special, long handled Allen head wrench. The set screw may be loosened and held in position while the shaft is turned by rotating the governor by hand. A clockwise rotation of the governor moves the pip on the oscillograph tape to the left. A rotation of 21.6 degrees of the governor moves the shutter pip 0.001 second.

Art. E_a-1.11. Master Contactor Adjustment. The master contactor should be adjusted so that each contact is made for 180 degrees of cam rotation, or $1\frac{1}{2}$ revolutions of the motor shaft. The dynamic method described in Art. E-3.01 of the "Airborne Manual 1945" should be checked by using an ohmmeter across each set of contacts and reading the average value of resistance. Contacts should be kept free from grease or dirt and the faces should be parallel.

CHAPTER E_a-2

MAIN FLASH UNIT AT-1 (MFU)

Art. E_a-2.01. Introduction. The Main Flash Unit AT-1, Figs. B_a-1.09, B_a-1.10, E_a-2.01 and E_a-2.02, was designed to provide the high voltage and the trigger voltage necessary to operate two Sylvania flash lamps; it operates from 28 volts direct current, an inverter being used to furnish the necessary 400-cycle single phase 115-volt alternating current. The block diagram, Fig. C_a-2.01, shows the relation of this unit to its companion units.

Art. E_a-2.02. Theory of Operation. Each component of this unit has a series letter denoting the functional classification of that part. These letters are as follows:

C	Capacitors	TR	Transformers
R	Resistors	CH	Chokes
T	Vacuum and gaseous tubes		

Reference is made to the circuit diagram, Drawing No. P38E-41-G44B. To start the unit, the 28-volt direct current from the SU is turned on, entering the unit through pins A and E of AN 3102-18-12P. This energizes relay 3, closing the normally open contacts and connecting 28 volts to the unit through pins A and B of AN 3102-20-23P. A 25-ampere circuit breaker switch is provided to protect the unit from overload. With the power on, the pilot lamp lights, and the inverter starts.

The 115-volt 400-cycle single-phase output of the inverter is brought into the unit through pins A and C of AN 3102-22-4P, connecting to the primary of TR-1. This connects filament voltage and high voltage (700 v. CT, RMS) to T-2 (5Y3GT/G), and filament voltage to the high voltage rectifier T-1 (816).

The rectified output of the low voltage supply is fed to a filter composed of CH-1 and C-4. The output of this supply energizes relay 1 through R-3, opening the normally closed contacts and closing the normally open contacts. When the MFU is used with the SU Mk III the normally closed contacts open and remove ground from the chain ground bus; the normally open contacts have no function. In the SU Mk IV the normally open contacts close and place ground on the hot-connected FLASH ON light in the SU and the normally closed contacts have no function.

The output of the low voltage supply charges C-4, C-5, and C-6 and C-7 through R-8 and R-9. The condenser-resistor combination C-4, R-4 through R-8 is one trigger circuit with C-6 and R-6 feeding the trigger pulse to the galvanometer. The other trigger circuit is composed of C-5, R-5 through R-9 with C-7 and R-7 feeding this trigger pulse to the oscillograph. R-10 and R-11 are bleeder resistors to lower the charging voltage on C-4 and C-5. Each trigger circuit is operated from a camera shutter through pins A and B on an AN 3102-16S-4P connector and switch S-1. This rotary switch allows each camera to operate a flash lamp independently (position 2), or one or the other input to operate both lamps (positions 1 or 3). When a camera shutter contact closes, shorting pins A and B on AN 3102-16S-4P, C-4 discharges through the primary of one high tension coil pin A of AN 3102-36-853 S; or if so connected, C-5 discharges through the primary of the second high tension coil, pin B on AN 3102-36-853 S.

Condensers C-6 and C-7 are discharged through R-6 and R-7 directly to galvanometer connector AN-3102-16--9P to supply the pulse for the oscillograph. The trigger pulse to the auxiliary flash units is a ground taken directly from the camera shutter contact pin B on AN 3102-16S-4P and fed to pin A on AN 3102-14S-9P.

When the READY switch on the MCU of the SU is closed, relay 2 is energized through R-12, closing contacts normally open. This connects the 115-volt, 400-cycle output of the inverter to the primary of TR-2 through a General Radio Company type 200-B Variac.

Resistors R-4 and R-5 serve as bleeders to prevent C-4 and C-5 from remaining charged when the unit is not in operation.

The high voltage alternating current output from the secondary of TR-2 is connected to the plate of T-1 (816). The positive side of the supply (filament center tap) is grounded, while the negative lead is connected through R-1 and R-2 to the high voltage condensers C-1 and C-2 respectively. Resistors R-13 through R-20 serve as bleeders to prevent C-1 and C-2 from remaining charged to dangerous potentials when the unit is not in operation.

Condensers C-1 and C-2 are charged to the full output voltage of the supply and then discharged through the flash lamps when the trigger circuit is energized, thus supplying the energy for the flash.

Art. E_a-2.03. Design Details. The Variac in this unit varies the high voltage output placed across the flashlamps. The dial is graduated directly in a-c volts from 0 to 130.

The circuit breaker switch supplies overload protection to the unit. It opens the d-c input circuit when a current greater than 25 amperes flows through it. It is located on the front panel and has a mechanical reset button.

CAUTION! When the circuit breaker blows, look for shorts, frayed wiring, pieces of solder between socket terminals, etc.

Resistors R-6 and R-7 vary the level of the d-c pulse to the galvanometer. They are screwdriver adjusting with a potentiometer lock which must be loosened before adjustment.

The transformers TR-3 and TR-4 in the trigger circuit are midget ignition coils of the type commonly used in miniature gasoline engine ignition systems.

When installing the flash lamps, it is necessary to use high-grade ceramic sockets. Due to the extremely high voltages present at the trigger pin of the socket, special precautions must be taken to insure the longest possible leakage path to ground. If possible glazed ceramic or silicone treated sockets should be used to inhibit the formation of large drops of water due to condensation resulting from changes in temperature.

Art. E_a-2.04. Operation. The operation of this flash unit is controlled from the MCU of the SU, as are all the units associated with it. To start all the units, turn on the POWER switch. This starts the 400-cycle 115-volt inverter. The READY switch of the MCU supplies a ground to energize relay 2 in the flash unit. The operation of relay 2 puts the high voltage direct current on the flash lamp energy storage capacitors. When the CAMERAS ON switch is turned on, the cameras start, triggering the lamps.

CAUTION! While general operating procedure allows sufficient time between turning on the POWER switch and the READY switch, in testing the units be sure to allow at least two minutes, in order to give the tube filaments a chance to warm up. No time delay circuits are incorporated to insure this.

Art. E_a-2.05. Maintenance. The components in this unit should be inspected periodically as a safeguard against rust and other corrosion. Socket connections and tube pins should be checked frequently for burning and corrosion, and burnished with crocus cloth as required. All screw-type connections should be checked for looseness and the leads dressed to prevent short circuit.

The relay contacts will require frequent cleaning with crocus cloth. Special attention should be paid to the carbon brushes in the Variac to insure against their becoming pitted and worn.

Occasionally it may be necessary to remove a tube from this unit. All the tubes are secured in their sockets by tube locks which keep them firmly in place under shock and vibration. These locks must be released before the tubes are removed. To remove a tube, lift the small lever that tightens the metal band around the base of the tube. The tube may now be withdrawn from the socket in the usual fashion.

It may be necessary from time to time to replace the electrolytic condensers in the unit because of drying out.

CHAPTER E_a-3

AUXILIARY FLASH UNIT (AFU)

Art. E_a-3.01. Introduction. The Auxiliary Flash Unit (AFU), Figs. B_a-1.09, E_a-3.01 and E_a-3.02, was designed to be used in conjunction with a Main Flash Unit (MFU). Its purpose is to allow the simultaneous operation of additional flash lamps in the system at points remote from the MFU. The block diagram, Fig. C_a-2.01, shows the relation of this unit to its companion units.

Art. E_a-3.02. Theory of Operation. Each component of the unit has a series letter denoting the functional classification of that part. These letters are as follows:

C	Capacitors	TR	Transformers
R	Resistors	CH	Chokes
T	Vacuum and gaseous tubes		

Reference is made to the circuit diagram, Drawing No. P22E-41-G45A. To start the unit, the 28-volt direct current from the SU is connected to pins A and E of AN 3102-18-12P. This energizes relay 3, closing contacts 3-NO and connecting the 28-volt direct current power to the unit through pins A and B of AN 3102-20-23P. A 25-ampere circuit breaker switch is provided to protect the unit from overload. With the power on, the pilot lamp lights, and the inverter starts.

The 115-volt, 400-cycle single phase output of the inverter is brought into the unit through pins A and C of AN 3102-22-4P, connecting directly to the primary of TR-1. This connects the filament voltage and the 700 volt (RMS) center-tapped high voltage to T-1 (5Y3GT/G), and filament voltage to the high voltage rectifier T-2 (816).

The rectified output of the low voltage supply is fed to a filter consisting of CH-1, C-2, and C-3. The output of this supply energizes relay 1 through R-2, opening contacts 1-NC and removing the ground from the chain ground shorting bus. The output of the low voltage supply powers the trigger circuit.

When the READY switch of the MCU of the SU is turned on, relay 2 is energized through R-15, closing contacts 2-NO. This connects the 115-volt, 400-cycle output of the inverter to the primary of TR-2 through a Variac.

The high voltage alternating current from the secondary of TR-2 is connected to the plate of the T-2 (816). The positive side of the supply, the filament center-tap, is grounded; the negative lead is connected through R-1 to the high voltage storage condenser C-1. Resistors R-7 through R-14 serve as bleeders to prevent C-1 from remaining charged to dangerous potentials when the unit is not in use.

Condenser C-1 is charged to the full output voltage of the supply and then discharged through the flash lamps when the trigger circuit is energized, thus supplying the energy for the flash lamp.

The trigger circuit works in conjunction with the trigger circuit in the MFU AT-1.

The output of the low voltage supply charges C-4, C-5 through R-3. A ground pulse from the camera shutter contact is received from the MFU through pin B of AN 3102-14S-9P. This shorts condenser C-4 and discharges it through pin A of AN 3102-36-853S into the primary of the trigger coil. This places a very high voltage on the trigger lead in the flash tube which ionizes the gas and causes it to fire. Resistor R-4 serves as a bleeder across C-4 to prevent the condenser from retaining its charge when the unit is not in use.

The ground pulse from the MFU also discharges C-5 through R-5 into the galvanometer connector AN 3102-16-9P which supplies the pulse for the oscillograph. Bleeder resistor R-6 lowers the charging voltage across C-4.

Art. E_a-3.03. Design Details. The Variac in this unit varies the high voltage output placed across the flash lamps.

The circuit breaker switch is an overload protection for the unit, opening the input circuit on more than 25 amperes. It is located on the front panel and has a mechanical reset button.

CAUTION! When the overload breaker blows, look for shorts, frayed wiring, pieces of solder between the terminals, etc.

The transformer TR-3 in the trigger circuit is a midget ignition coil of the type commonly used in miniature gasoline engine ignition systems.

When installing the flash lamps, it is necessary to use high-grade ceramic sockets. Due to the high voltages present at the trigger pin of the socket, special precautions must be taken to insure the longest possible leakage path to ground. If possible, glazed ceramic or silicone treated sockets should be used to inhibit the formation of large drops of water due to condensation resulting from changes in temperature.

In view of the high peak current and the high voltage present at the output terminals, high voltage, high current cable must be used between the unit and the flash lamps. The high voltage cable must be as short as possible and should not exceed ten feet as a maximum.

Art. E_a-3.04. Operation. The operation of this unit is controlled from the MCU of the SU, as are all the units associated with it. To start all the units, turn on the POWER switch. This starts the inverter. The READY switch of the MCU supplies a ground to energize relay 2 in the MFU and the AFU's. The operation of relay 2 puts the high voltage direct current output on the flash lamp energy storage capacitors.

CAUTION! While general operating procedure allows sufficient time between turning on the POWER switch and the READY switch, in testing these units, be sure to allow at least two minutes in order to allow the tube filaments to warm up.

Art. E_a-3.05. Maintenance. The components in this unit should be inspected periodically as a safeguard against rust and other corrosion. Socket connections and tube pins should be checked frequently for burning or corrosion, and burnished with crocus cloth as required. All screw-type connections should be checked for looseness and the leads dressed to prevent short circuits.

The relay contacts will require frequent cleaning with crocus cloth. Special attention should be paid to the carbon brush in the Variac to insure against its becoming pitted and worn.

Occasionally it may be necessary to remove a tube from the unit. All the tubes are secured in their sockets with tube locks which keep them firmly in place under shock and vibration. These locks must be loosened before the tubes are removed from their sockets. To remove a tube, lift the small lever that tightens the metal band around the base of the tube. The tube is then free and may be withdrawn from its socket in the usual manner.

The Variac shaft is locked by a setscrew which must be loosened before attempting adjustment. The adjustable resistors are fitted with potentiometer locks which must be loosened prior to adjustment.

The electrolytic condenser may need replacement if it dries out.

CHAPTER E_a-4

FIGHTER FLASH UNIT NO. 1 (FFU)

Art. E_a-4.01. Introduction. The Fighter Flash Unit (FFU), Figs. E_a-4.01 to E_a-4.03, was designed to supply the high voltage necessary to operate two Sylvania type R4350 or four Sylvania type SA309 photoflash lamps. It is also possible to operate one type R4350 and two SA309 flash lamps simultaneously. The output voltage is variable from the front panel in four steps to suit the needs of the operator.

The unit is a vibrator type power supply, converting the aircraft 28-volt direct current into the high voltage necessary to operate the flashlamps. There is also a second smaller supply in the unit which supplies the direct current pulse necessary to trigger the flashlamps.

Art. E_a-4.02. Theory of Operation. Each component of this unit has a series letter which shows the functional classification of the part. These letters are as follows:

C	Capacitors	S	Switches
F	Fuses	T	Transformers
R	Resistors	SR	Selenium Rectifiers

Refer to the circuit diagram, Drawing No. AML-41-G45.1. The input voltage is brought into the unit through pins A and C on AN 3102-14S-2S, the positive lead going through a five-ampere fuse to protect the unit from accidental overload. The dial lamp lights when the unit is in operation. Both the fuse and the dial lamp are on the front panel.

Resistor R-1 is necessary in order to reduce the voltage applied to the vibrator coil to its rated value. Capacitors C-8 and C-9 serve to suppress arcing at the vibrator contacts, as does C-13 across the coil contact. The switch, S-1 on the rear drop of the chassis, is used to switch the output of the vibrator from one set of contacts to the other, should this be necessary due to the failure of one set of contacts.

Resistor R-3 is used to reduce the load on the vibrator while it is starting. When the unit is started, the full resistance of R-3 is in series with the positive lead. After a short delay, relay A operates, shorting out all but about half an ohm of R-3 and bringing the output up to full voltage. The time delay on relay A consists of capacitor C-7 charging through R-2, giving a time delay of approximately one second, sufficient time for the vibrator to reach full speed.

The vibrator operates in a standard vibrator circuit, interrupting the circuit periodically at a frequency of about 70 vibrations per second. The input voltage is applied first to one half the primary winding, then in the opposite direction across the other half. This induces an alternating voltage in the secondary winding, the magnitude of which is dependent upon the input voltage and the turns ratio of the transformer.

Capacitor C-5 is used as a buffer, to suppress the high-peaked transients resulting from the peaked square wave form of the vibrator output. Switch S-2 serves to vary the output voltage as required. It is mounted on the front panel, between the fuse and the dial lamp.

The high voltage selenium rectifiers SR-1 and SR-2 are arranged in a voltage doubling circuit. It is very important that the red ends of the rectifiers be placed in the red painted fuse clips. Capacitors C-3 and C-4 are charged on alternate pulses, their outputs adding in series. The maximum possible output voltage from a circuit of this type is twice the peak a-c voltage across the transformer secondary. The bleeder resistor R-8 prevents C-1, C-2, C-3, and C-4 from remaining charged to dangerous potentials when the unit is not in use.

Caution! Always allow at least five minutes after turning off the unit before starting to work on it. Always short all capacitors before starting to work.

Capacitors C-1 and C-2 are charged to the full output voltage of the supply, being discharged through the flashlamps to supply the energy for the flash. Resistors R-9 and R-10 are used to protect the supply from overload when the capacitors are discharged.

The smaller of the two secondary windings feeds into a half wave selenium rectifier, charging C-6. When the shutter contacts close, connecting the lower end of R-6 to ground, capacitors C-10 and C-11 discharge through the primary windings of the midget ignition coils. This places a very high potential on the trigger wires inside the flash lamp, ionizing the gas and allowing C-1 and C-2 to discharge through the lamps. Bleeder resistors R-11 and R-12 prevent C-6, C-10, C-11, and C-12 from remaining charged when the unit is not in use.

Since the full output voltage from the small supply was found to be too high, the output was tapped down on the voltage divider formed by R-5 and R-13. Resistor R-5 also serves to protect the supply from overload when C-10 and C-11 are discharged.

The potentiometer R-7 varies the level of the pulse to the recording galvanometer.

When operating two SA309 flashlamps from one plug on this unit, the lamps must always be connected in series across the supply. If the lamps are placed in parallel, differences in the characteristics will cause one lamp to flash ahead of the other, discharging the capacitor, and the second lamp will not flash.

Art. E_a-4.03. Design Details. The Fighter Flash Unit is designed to operate from a 28-volt direct current source. Under normal operating conditions, its power consumption is between 56 watts and 126 watts, depending upon the number of flashlamps in the load and upon the position of the voltage selector switch S-2. The exact values of the current drawn from the line under various operating conditions will be found in the test data.

The transformers used in the trigger circuit are midget ignition coils of the type commonly used in miniature gasoline motor ignition systems.

When installing the flash lamps, it is necessary to use high grade ceramic sockets. Due to the extremely high voltages present at the trigger pin on the socket, special precautions must be taken to insure the longest possible leakage path to ground. If possible, use glazed ceramic or silicone treated sockets to inhibit the formation of large drops of water due to condensation from changes in temperature.

Due to the very high voltages and currents present during the flash, the cable connecting this unit with the flash lamps must be of the high-voltage, high-current type.

The output connectors have been modified for use in this unit, pins A, B, C, E, F, and G having been removed in order to increase the leakage path to ground and guard against flashover.

Art. E_a-4.04. Operation. The operation of the Fighter Flash Unit is entirely automatic, once it has been turned on.

To start the Fighter Flash Unit, it is only necessary to apply 28-volt direct current to pins A and C of AN 3102-14S-2S. To operate the flashlamps, it is necessary to trigger the unit, placing the shutter contacts across pins A and D of AN 3102-14S-2S.

Switch S-2 is located on the front panel and varies the output voltage in four steps, to suit the needs of the operator.

Switch S-1 is located on the rear drop of the chassis. It serves to change the output of the vibrator from one set of contacts to the other, should this be necessary due to the failure of one set of contacts.

Potentiometer R-7 varies the level of the d-c pulse to the oscillograph and is located on the top of the chassis, directly behind S-2. It is screwdriver adjusting and is provided with a potentiometer lock. In order to adjust this control, it is necessary to first loosen the pot lock (top nut only).

In order to change the time delay period of relay A, the value of either R-2 or C-7 must be changed, a larger value of either giving a longer time delay. Since the relay closure is not positive with values of R-2 larger than 750 ohms, it is recommended that the size of C-7 be increased to give a longer time delay.

If it is desired to increase or decrease the output of the unit slightly, the tap on the five-ohm variable resistor R-3 may be varied, since an increased resistance left in the circuit on closing of the relay contacts results in a lower output voltage.

If it is desired to change only the trigger voltage, C-10 and C-11 may be tapped up or down on the voltage divider formed by R-5 and R-13.

To facilitate the adjustment of this unit, waveforms of various important currents are shown on the schematic diagram, Drawing No. AML-41-G45.1. All waveforms shown were measured from the points indicated to ground with a Dumont 208B oscilloscope.

The level of the galvanometer waveform is variable by means of the potentiometer R-7. It shows the charge and discharge curve of C-12 with each flash of the lamps.

The shutter waveform shows the charge curve of C-12.

The trigger waveform shows the oscillatory nature of the discharge of C-11 through the primary of the midget ignition coil.

Art. E_a-4.05. Maintenance. No maintenance should be attempted without first removing the unit from its cabinet.

Caution! Always short all capacitors to make sure that all components are safe to handle.

The most likely source of trouble in this unit is the vibrator, which will need attention periodically, depending upon the amount of time it has been used and how great a load has been placed upon it. To remove the vibrator from the unit, it is first necessary to remove its cover. Using a six-inch screwdriver, it is possible to remove the screw on the right-hand end, the screwdriver blade being inserted under the rectifiers and the relay coil to reach the screw head.

With the cover off, the two screws, one at each end, holding the vibrator to the chassis, must be removed. It is best to hold the nuts underneath the chassis with a 5/16-in. socket wrench.

Another important and likely source of trouble are the high-voltage rectifiers. This unit was designed for operation for short periods of time only; it is not a continuous duty apparatus. The rectifiers are overloaded during normal operation, but this is permissible since selenium will stand large overloads for short periods of time.

The unit should never be operated for more than two minutes, and never run for so long a time that the rectifiers become warm to the touch and cloudy on the inside of the glass shell.

The two electrolytic condensers may require replacing. Capacitor C-7 will be damaged if the direct current input to the unit is applied in the wrong polarity; pin C should always be positive. Capacitor C-6 will be injured if the rectifier SR-3 is connected backwards. This may be readily discovered, since there will be no output voltage from the trigger supply with the rectifier backwards.

Replacements of most components may be made from the spare parts accompanying this unit. All replacements should, of course, have the same electrical characteristics as the parts they replace.

All contacts in this unit will need periodic inspection and cleaning if maximum operating efficiency is to be realized. The contacts may be cleaned with crocus cloth or fine sandpaper; never use emery cloth.

In tests made on this unit, it was found that the vibrator tended to arc when the unit was operated unloaded. When operating under load, there was very little, if any, spark visible, the capacitors C-8 and C-9 being sufficient to suppress any tendency to arc. For this reason this unit should never be operated without a flashlamp load.

CHAPTER E_a-5

THE GYRO ATTITUDE RECORDER

Art. E_a-5.01. Maintenance. The maintenance required for the operation of the gyroscope assembly includes the precautions that (1) no adjustment of the leveling screws be made after the instrument is installed, (2) that extreme caution be used to prevent bumping or displacement of the gyroscope elements, (3) that no dust or dirt of abnormal nature be allowed in the vicinity of the gyroscopes and (4) that the covers of the units be left intact to prevent dust from entering the ball-bearing areas.

These instruments are built with extreme precision and assembled with great care. If any element is found to be loose or inactive or responding improperly to the necessary motion and displacements, any repair or adjustment should be attempted only if there is no possibility of inaccurate functioning afterwards. The various units should be considered as a whole since adjustments of the components may seriously impair the accuracy of the operation. See Chap. D-3, "Airborne Manual, 1945."

Certain difficulties in the operation of the electrical apparatus in this equipment may be rectified in the field if proper precautions are taken. For example, if the erection mechanism of the horizontal gyro does not perform satisfactorily, the covers may be removed to adjust the position of displaced finger contacts after the area has been made dust free. The covers must be replaced as soon as possible and extreme care must be exercised to be certain the parts are reassembled on the dowels and locking or locating elements to assure accuracy of alignment. After such adjustment, the unit should be retested to ascertain if its operation is proper. Excessive drag of electrical contacts on commutators and slip rings must be avoided. It is therefore recommended that only minor maintenance be done in the field to preserve the original accuracy of alignment and operation.

The mirrors and windows should be kept clean and free from lint. The external connecting nuts and bolts should be checked carefully to be certain no loosening has occurred after installation. If the operation of the gyroscopes gives any indication of malfunction, another unit of known characteristics should be substituted.

Art. E_a-5.02. Checking. Field checks of the operation of the gyroscope assembly include general observation of the erection response and flight tests to determine if the operation of the gyroscopes is satisfactory.

Flight tests for this purpose are made by flying the aircraft straight and level, erecting and caging the gyroscopes, uncaging and performing approximately six seconds of evasive action, and returning to straight and level flight with as nearly as possible the same direction and attitude as at the beginning of the test. The photographic readings of the dials at the beginning and end of the test with free gyroscopes should read approximately the same, within the limits of the pilot or the auto-pilot to reproduce direction and attitude. The attitudes may be approximately checked by observing the positions on the accelerometers.

Several such tests would be made on one film and the beginning and end of each test would be analyzed for comparison. If a difference of several degrees was observed for each test, it would be evident that the gyroscopes were not performing correctly. Such tests are necessary before and after each series of data-recording flights.

When the gyroscope unit fails to respond to these primary tests the units should be overhauled and re-aligned. At this time checks should be made to be certain that the measurements obtained on the units are accurate. This work is done by assembly on a test turret-Scorsby machine now at Armament Test, US NATC, Patuxent River, Maryland.

Art. E_a-5.03. Overhaul. The two sets of M-H (Norden) gyroscopes which are designated as No. 11 and No. 12 are subject to overhaul as follows:

A. At Least Once Each Year.

The annual overhaul is necessary to clean the ball-bearings of dust and oily gums, to lubricate the moving parts, to check the positioning of the dials, and to maintain the operating accuracy of the gyroscope elements.

B. After 50 Hours of Operation.

The 50-hour overhaul and lubrication is observed from the "Handbook of Operation and Service Instructions" for C-1 Autopilots, designated AN 11-60AA-1. In order to lubricate the various bearings and surfaces it is necessary to dismantle parts of the gyroscopes. At the same time it is recommended that the gyroscopes be completely disassembled and all the operating elements checked. In this manner the highest degree of accuracy may be maintained. The 50-hours operating time includes all time during which power is applied to the gyroscopes.

C. Check of Flight-Test Performance.

Flight tests which determine if the operation of the gyroscopes is satisfactory are made by flying the aircraft straight and level, erecting and caging the gyroscopes, uncaging and performing approximately six seconds of evasive action, and returning to the straight and level flight with as nearly as possible the same direction and attitude of pitch and roll as at the beginning and end of the test.

The gyroscopes are completely disassembled and all parts are examined to determine if any changes from the original may be observed so that parts may be replaced. The bearings are checked for tightness and operating smoothness.

After completely dismantling and checking all the parts, the instruments are re-assembled in the same manner as discussed in the construction tests described in the "Manual on Accuracy Tests of Individual Gyro Units, Gyro Assembly and Overhaul" (J. J. Ryan, August 4, 1948).

The overhaul of these gyros is an identical operation to the original tests established for the development of the modified gyros. The gyroscopes are assembled on the bedplate after individual tests are finally checked by the moving platform tests on the turret-Scorsby.

APPENDIX A_a*

THE SYNCH SYSTEM Mk IV

INTRODUCTION

To complement the Mk III synch system permanent setup in the Fire Control PB4Y-2, AT 24, Northwestern University was requested by the Fire Control Department to build a portable synch system comparable in all its functions to the Mk III, but smaller, lighter, and more compact: this portable system is known as the Mk IV. The considerations of weight and size were to be primary in this design, rather than secondary as in the Mk III. The unit was to be used in transient aircraft brought to Patuxent for test and for equipment which could not be tested in the PB4Y-2 master synch system. After several preliminary discussions with Mr. Pierson of the Fire Control Department, design was begun on December 1, 1947.

MECHANICAL DESIGN

The Mk III synch, comprised mainly of the SU and its separate MCU, was studied to determine where the most logical reduction in size could be made. Since the Mk IV would be used primarily for temporary projects, and since almost all Navy bombers have a navigator's compartment of some sort, it was thought possible that a single unit, comprised of SU and MCU, could be made to use in the navigator's compartment. It was found that this could be accomplished using a case approximately $18\frac{1}{2}$ in. long, $10\frac{1}{2}$ in. high and $10\frac{1}{2}$ in. deep, as shown in Fig. B_a-1.06.

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* This Appendix has been taken from "Mark IV Synch System Design Report" by W. S. Toth (May 4, 1948). A brief of the Report has appeared as AML Memo No. 73 (June 10, 1948).

To simplify recognition of the controls during operation, the front panel of the unit was laid out in three separate sections. The center section, set forward from the two side sections by 3/4 in., contains the controls necessary for operation in flight (formerly MCU). The left panel contains all pre-flight controls, which, once set, do not have to be used during flight. The right panel contains lights and meters for operation indications and the master switch for the SU and for the BLINK. Since the necessary Amphenol connectors require $3\frac{1}{2}$ inches, the top panel was recessed by this distance to accomodate the connectors. The top panel was chosen because in most installations the greatest space available for cable runs is overhead, and connectors brought down to the unit from above take up the least amount of space. All panels on this unit are removable from a welded frame except the panel which holds the Amphenol connectors. This panel is hinged so that the connectors may be exposed for work. All panels are 0.091 in. aluminum, except the Amphenol connector panel, which is 1/8 in.; the frame is 1/2-in. aluminum angle, and the entire unit is finished in black crackle paint.

ELECTRICAL DESIGN

First consideration in the electrical design was the elimination of all components not necessary for the actual function of the primary controls, READY, START, TIMING, and CATALOG. In the place of the automatic monitoring accomplished by the chain ground in the Mk III system, it was felt that the space saved by eliminating this feature warranted substitution of manual monitoring. This did not in any way alter the sequence of operations, but eliminated the fuse relays, enabling the Mk IV to be designed using only eight relays, six of which are the midget aircraft type. In order to indicate operation of related units such as the MFU and the BLINK transmitter, signal lights were placed on the front panel: if a unit is in operation a panel light is on; if the unit is not in operation the panel light is off. An additional precaution was added to the master motor circuit. A panel light indicates 110-volts alternating current from the inverter and an a-c meter indicates the voltage at the master motor. Because ± 1.5-volt regulation must be maintained in the d-c input to the synch system, it is monitored by a d-c voltmeter. Thus the MCO can tell at any time the exact state of the power supplies to the system and thereby be sure of his synch control. The unit handles three turret outlets, six synchronized camera outlets, one oscillograph recorder, two flash units and one FLINK-BLINK unit. No oscillograph patch panel is needed with the unit since 12 traces are to be recorded on the 12-channel oscillograph. All Amphenol connectors have been so chosen that the unit is interchangeable with the Mk III.

SEQUENCE OF OPERATIONS IN Mk IV SYNCH (Refer to circuit diagram, Drawing No. P22E-41-B30.2, available at Patuxent and Evanston.)

A. Turn on D.C. POWER switch of SU (Fig. B_a-1.06).

1. The power signal light comes on.
2. Meter D.C. VOLTS reads 28.5.
3. The AC light comes on.
4. Meter A.C. VOLTS reads 120.
5. The master motor starts.
6. The timing pulse starts.
7. The TIMING light indicates once per second on front panel.
8. The thread power is available.
9. The MFU is supplied with 28.5 volts direct current.

B. Dial attack number on SU.

1. This transfers the chassis ground onto the dial ground bus.
2. One side of the DIAL RESET button is now grounded. If the MCO dialed incorrectly, pushing the DIAL RESET button energizes the dial release relay C and releases the dial.

C. Push the READY button of OCU.

1. This energizes relay A, which is held up through its own holding contacts, turning on READY light and transferring dial ground to the ready ground bus.

2. This energizes relay E, closing plate circuit of BLINK transmitter, starting the transmitter if the BLINK ON switch is on.

3. This transfers ready ground to flash unit to close high voltage circuit in the flash. A panel light, FLASH ON, indicates when high voltage is on.

4. This supplies ready ground pulse to BLINK transmitter.

D. Push START button of OCU.

1. Relay B is energized, and held up through its own holding contacts, opening READY light circuit, opening DIAL RESET circuit, closing RUNS counter circuit, and transferring READY ground to START ground bus.

2. This turns on panel START light.

3. This energizes relay P, placing 28 volts on the camera bus.

4. This energizes relay D, placing the SECONDS counter circuit onto TIMING ground pulse so that it counts once per second.

E. Push CATALOG button of OCU.

1. This energizes relay C, releasing dial.

2. This energizes RUNS counter causing it to count number of pulses from the dial.

3. The catalog relay and CATALOG light are pulsed corresponding to number set on dial.

4. The timing holdup relay is energized so that only cataloging is put onto the film without interference from timing. The Mk IV has the same timing and cataloging circuit as the Mk III, i.e., double timing marks and single cataloging marks, with both pulses recorded on the oscillograph.

Note: Releasing dial, releases ground from dial ground bus, ready ground bus, and start ground bus in turn, and stops operation.

APPENDIX B_a*

THE FLINK-BLINK

INTRODUCTION.

The FLINK-BLINK for the camera synch system uses two modified FM drone units, the ARW-3 transmitter and the ARW-17 receiver. These units operate at approximately 36 megacycles and were chosen for remote camera control use to take advantage of the static-free FM.

In order that the fighter data be accurately tied to the bomber data, some signal common to both the bomber and fighter is needed. The obvious method would seem to be to use the timing pulse from the bomber. However, if this pulse (converted to a light beam) were put on the fighter film which is not necessarily at rest at the same instant the bomber film is motionless, the timing marks would be indistinct. To overcome this difficulty, the films in the fighter are marked using the synch source in the fighter, thus tieing all fighter films together. This timing is recorded on the fighter oscillograph, and in addition, the timing pulse from the bomber is transmitted to the fighter oscillograph, giving the bomber reference. All bomber film is then read at bomber time and all fighter film is read at fighter time. The difference, constant in any run, can be accurately read from the fighter tape.

The complete system is comprised of the following units:

1. The ARW-3 transmitter (BLINK transmitter).
2. The ARW-17 receiver (FLINK receiver).
3. The FLINK Conversion Unit (FCU).
4. The Automatic-Manual Box (AMB).

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*This Appendix has been taken from "Report on Drone Gear Redesign for FLINK BLINK" by W. S. Toth (July 2, 1948).

MECHANICAL DESIGN

The physical layout of the transmitter and receiver were altered only to the extent that shock mounts were added. The FCU is a heavy gauge (.064) aluminum box 12 x 7 x 6½ in. The front panel contains the 14 Amphenol connectors needed to tie this unit to the rest of the system. No controls are mounted on this unit. The AMB Box is 6 x 4 x 1½ in. It is mounted in the cockpit so that the broad side is across the skin of the aircraft. The indicator lights and switches are mounted on the narrow side of the box. This gives the pilot full view of his controls and takes up the minimum amount of space.

ELECTRICAL DESIGN

1. The ARW-3 transmitter (BLINK transmitter).

To tie the transmitter control into the synch system, the plate switch was removed, and the plates are now energized from the CAMERA ON signal of the synch system. Of the ten available channels, four were closed to transmit the synch unit signals to the remote unit. These signals are READY, START, TIMING, and CATALOG. To energize the transmitter channels, only a ground is necessary. These grounds are supplied entirely by the synch unit and no intermediate circuits are needed. The signals are so arranged in the synch unit that only two channels in the transmitter are energized at any one time. This allows modulation to 33 percent with provision for an added channel if needed for special work.

2. The ARW-17 receiver (FLINK receiver).

The operation signals transmitted from the ARW-3 are received in the ARW-17, demodulated, and sent to tuned audio circuits. Each control signal, READY, START, TIMING or CATALOG, energizes its own tuned circuit and in the case of READY, START and CATALOG, a relay in that circuit. In the case of TIMING a rectifier circuit was built to convert the timing channel of 1617-cycle frequency into a pulse which can be recorded on the oscillograph. The timing relay in the receiver was removed.

3. The FLINK Conversion Unit (FCU).

The conversion unit is so named because it takes the signals from the channels in the receiver and converts them to voltages correctly applied to operate the cameras. This unit is in reality a miniature synch system which operates the cameras from the signals received in the FLINK (ARW-17) receiver. It is built to operate five 35-mm cameras and one oscillograph recorder. It is wired to operate a fighter flash unit (FFU) and has an auxiliary power outlet to furnish voltage for photo-panels and instrument cameras.

Since the unit is used in fighter aircraft, it is conceivable that there would be need to operate the unit manually, i.e., without remote control. Such a feature was provided for in the Automatic-Manual Box (AMB). This control box allows the pilot to use manual control, running the cameras by means of the pickle switch on the control stick of the plane.

4. The Automatic-Manual Box (AMB).

This control box, though an integral part of the FLINK conversion unit, was built independently so that it could be mounted in the cockpit of the aircraft within easy reach of the pilot.

The box contains two switches, POWER ON, in parallel with FLINK Conversion Unit POWER ON switch, and the AUTOMATIC-MANUAL switch, and five lights, POWER ON, READY, START, TIMING and CATALOG. A camera outlet in the cockpit is wired from the conversion unit to permit mounting a camera in the cockpit. The timing and cataloging lights in this box are connected directly to the timing and cataloging busses so that they indicate these functions exactly as they occur in the camera.

SEQUENCE OF OPERATION

Refer to drawing Nos. P22E-41-E51.1 and P22E-41-E51.2, available in Patuxent or Evanston, when reading the following:

1. The main power switch is turned on. The AUTOMATIC-MANUAL switch of the AMB is switched to AUTOMATIC.

   a. Power relay A closes.

   b. 28 v. direct current power through contacts A is supplied to the tuning fork inverter, oscillograph, threading on all cameras, and the AMB.

   c. POWER ON light glows in AMB.

   d. The tuning fork inverter starts, a-c 110 v. power comes on and the master motor starts.

   e. The timing micro-switch operates once per second from the master motor.

   f. Power is supplied to the FLINK receiver and signals transmitted by the bomber are received.

It is assumed in discussing the automatic operation of this circuit that the bomber is transmitting the required signals to the FLINK receiver.

2. Energizing the synch system in the bomber starts the timing circuit in the bomber which is received on the channel of 1617 cycles and rectified through a specially connected 6J6 (see drawing No. P22E-41-E51). This produces a pulse output every time the timing circuit is energized in the bomber (once per second); this pulse is put directly into the oscillograph as the bomber reference timing mark.

3. "Readying" the synch system in the bomber transmits a 4512-cycle signal to the fighter which closes a relay in the 4512-cycle channel in the receiver. The normally open contacts of this relay close and place ground on the ready lamp (battery connected) in the AMB (through the conversion unit). This indicates to the fighter pilot that the system is ready to record.

4. "Starting" the synch system in the bomber transmits a 2297-cycle signal to the fighter which closes a relay in the 2297-cycle channel in the receiver. The normally open contacts of this relay close and place ground on CAMERAS ON relay B in the conversion unit. The START signal in the bomber synch

system automatically removes the READY signal from the transmitter by opening a normally closed contact in the ready circuit to the transmitter.

a. Normally open contacts on relay B close placing direct current (24 v.) on CAMERAS ON bus, energizing the TIMING relay D. This relay D then operates once per second through the timing micro-switch on the master motor.

b. Relay G in parallel with relay B pulls up with CAMERAS ON signal. The normally open contacts of relay G close placing direct current (24 v.) on oscillograph circuit. The relay G is a fast-acting midget relay and is used here so that the oscillograph circuit is independent of the CAMERA ON circuit. This insures that the oscillograph galvanometers receive no inductive surges.

c. The normally open contacts on relay D close once per second energizing the timing circuit placing fighter timing on both timing and cataloging bus and the oscillograph. This gives double timing lights on the film. Timing is indicated in the AMB.

d. Direct current of 24 volts from CAMERAS ON bus to ground connected CAMERAS ON light energizes this light in the AMB.

5. When the CATALOG circuit is made in the bomber the timing in the bomber is automatically removed.

The catalog circuit transmits a 3262-cycle signal to the fighter which operates a relay in the 3262-cycle channel of the receiver.

a. The normally open contacts of this relay close, placing ground on the battery connected "catalog" relay E.

b. One pair of the two normally open contacts on this relay places ground on battery connected "timing holdup" relay C which is held up through its own holding contacts. This causes the break-make contacts of relay C to open the timing bus and place a dummy load on the catalog bus.

The second pair of normally open contacts on the catalog relay E pulses the catalog circuit putting the correct number of catalog marks on the film and oscillograph. This gives single catalog lights on film.

All channels are de-energized at the transmitter when the synch system stops, thus stopping all channels in the fighter.

When operating the FLINK Conversion Unit on manual (AMB manual switch in Manual position) the READY light is energized from the switch when the main power switch is turned on. When the pilot is ready to photograph, he presses the pickle-switch on the control stick.

1. This places direct current (24 v.) on ground connected "firing" relay F.

2. The normally open contacts of this relay close, placing ground on battery connected "cameras on" relay B.

3. Normally open contacts of "cameras on" relay B close, energizing camera bus and timing relay D, which in turn operates fighter timing as in automatic operation.

As long as the pickle-switch is closed the cameras run. As soon as the pickle-switch is released the relay F releases the "cameras on" relay B and stops the system. There is no cataloging in manual operation.

PARTS LIST

An itemized list of parts, and the source from which they may be obtained, is not included in this First Supplement; the pertinent information is given on the drawings available at Patuxent from the Executive Officer of Armament Test, or at AML, Northwestern University, Evanston, Illinois.

Two components, the Oscillograph Recorder and the Tuning Fork Inverter, were purchased from the Heiland Research Corporation; any replacements for these two units should be obtained directly from the Heiland Research Corporation, 130 East Fifth Avenue, Denver, Colorado.

DRAWINGS LIST

Operating experience at U.S.N.A.T.C. Patuxent River has demonstrated that while certain drawings are needed for ready reference the bulk of drawings are not, even though the latter are necessary for construction purposes. In consequence, only those drawings most frequently used by the operating personnel are listed in the left-hand section. The rest of the drawings are available at Patuxent from the Executive Officer of Armament Test; or at AML, Northwestern University, Evanston, Illinois.

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System Operation:	Walter S. Toth
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AERIAL MEASUREMENTS LABORATORY PERSONNEL

The following is a complete list of the staff of AML as of May 1949, and includes the permanent staff as well as those employed to meet the shifting burdens.

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Sidney J. Horwitz	Electrical Engineer	Earle J. Hancock	Computer
Herbert R. Johnston	Electrical Engineer	Robert C. Schneider	Computer
Richard L. Petritz	Electrical Engineer		
Herbert W. Schultz	Electrical Engineer	Richard B. McFarland	Superv. Elect. Tech.
Walter S. Toth	Electrical Engineer	Edmund U. Cohler	Electrical Technician
Viola J. White	Electrical Engineer	John R. Duncan	Electrical Technician
		Theodore Meyers	Electrical Technician
Milton R. Nielsen	Mechanical Engineer	Joseph B. Naines, Jr.	Electrical Technician
James J. Ryan**	Mechanical Engineer	Herbert J. Nelson, Jr.	Electrical Technician
Rodney J. Schaid	Mechanical Engineer	Jack A. Rudolph	Electrical Technician
		Daniel J. Siwy	Electrical Technician
Clarence T. Allen	Processing Engineer	C. Keith Stenerson	Electrical Technician
Robert A. Woodson	Physicist		

Elliott L. Buell	Mathematician
James P. Corbett	Mathematician
Nye F. Morehouse, Jr.	Mathematician
Marjorie J. Wiley	Mathematician

*AML representative at U.S.N.A.T.C., Patuxent River, Maryland

**Subcontractor, at University of Minnesota.